LHC First Physics Results

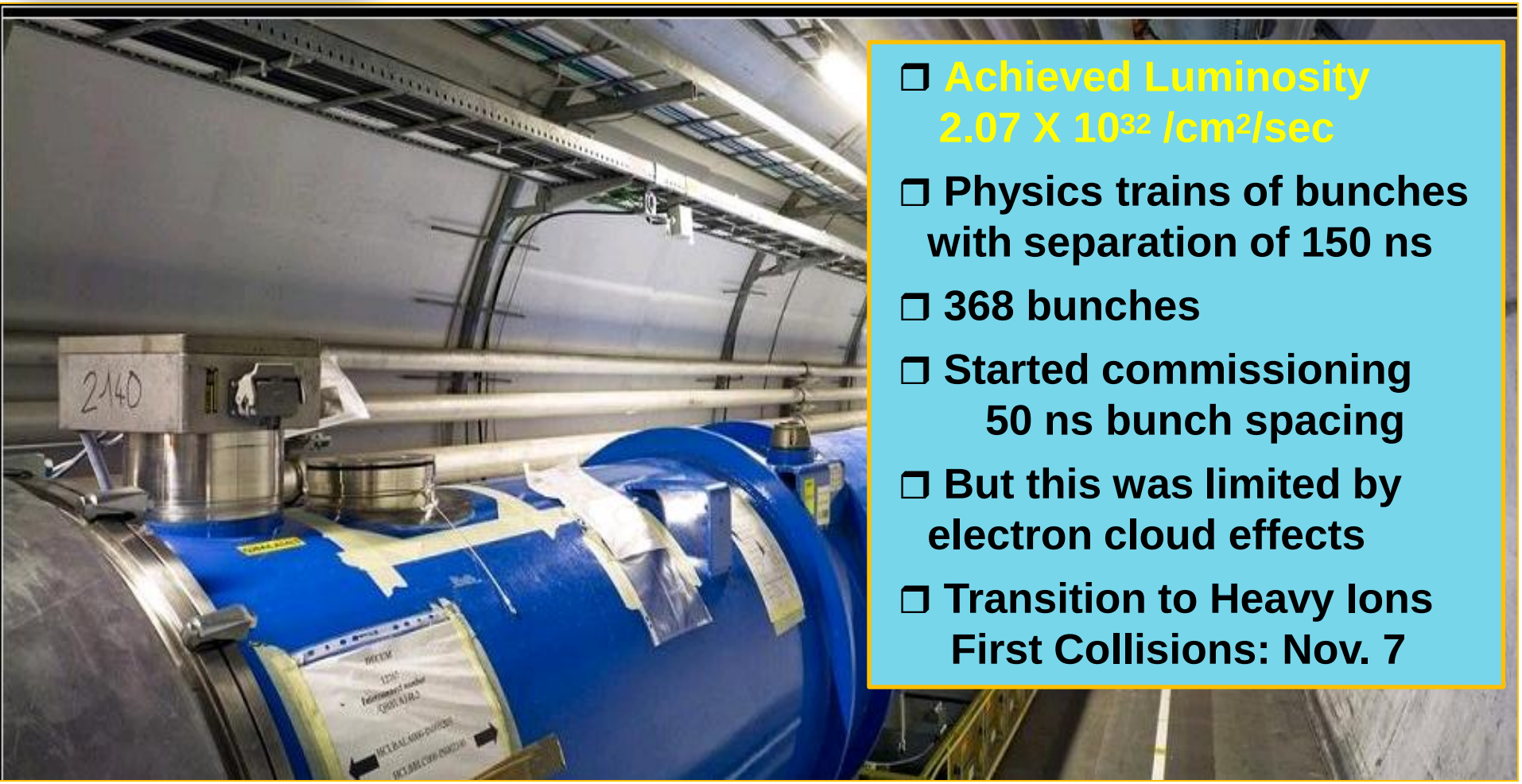
Howard Gordon
BNL
For the U.S. ATLAS, U.S. CMS, U.S. LHCb and U.S. ALICE Collaborations

Special thanks to Joel Butler, Pippa Wells, Harvey Newman, Sheldon Stone and John Harris

General Status

- 2010 has been a spectacular year for the LHC
  - pp collisions started on March 30, 2010
  - The machine has increased the instantaneous luminosity for pp by 5 orders of magnitude to ~$2\times10^{32}cm^{-2}s^{-1}$
  - All four major experiments have taken a large data set (~45 pb^{-1} for ATLAS and CMS) with all systems working well
  - Many publications have come out already and many more are in the pipeline – some new phenomena, some limits beyond the Tevatron
  - Fundamental measurements have been made which are critical for determining the backgrounds for such major discoveries as SUSY or the Higgs

US LHC and the LHC Program



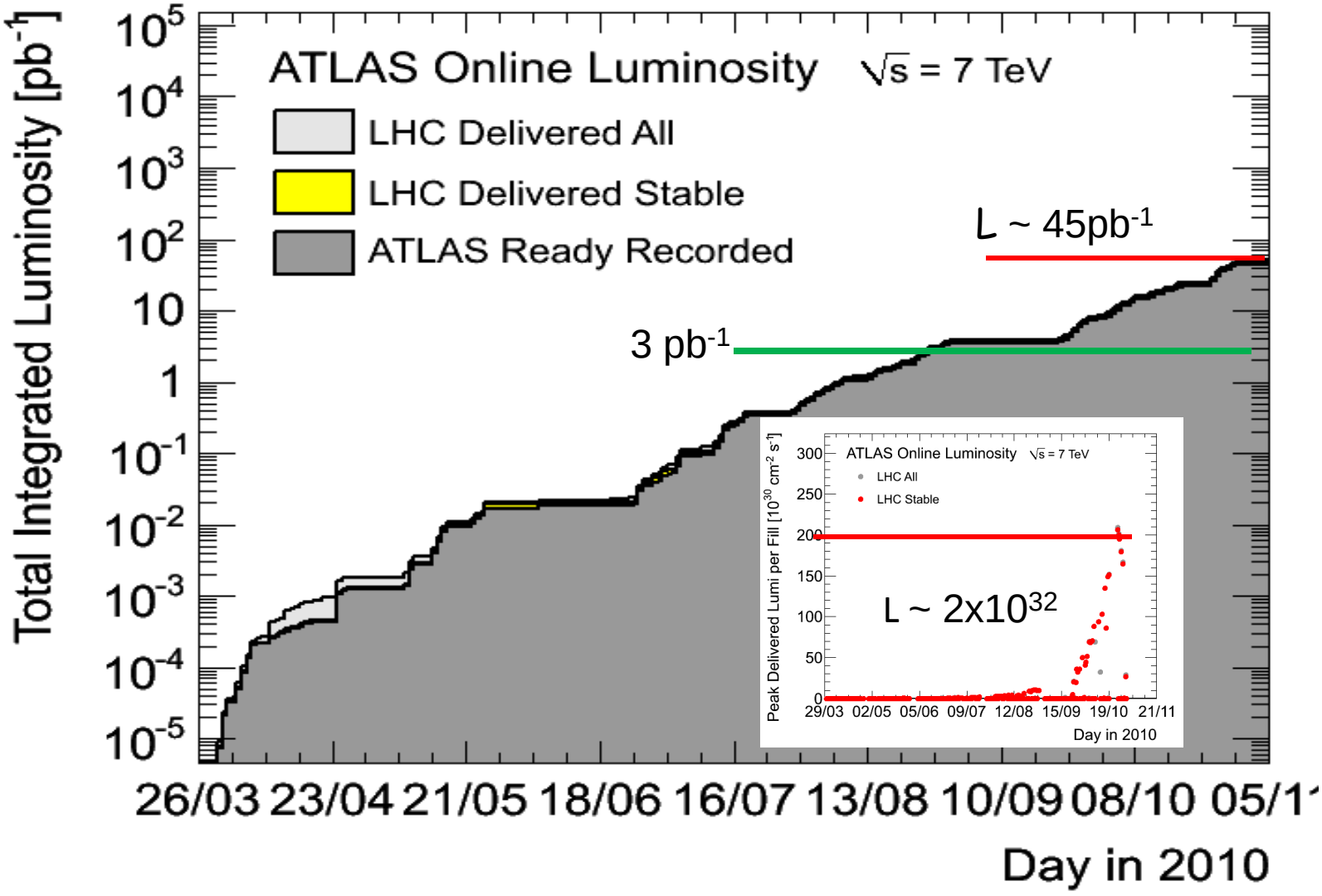
- Achieved Luminosity
  2.07×10^{32} /cm²/sec
- Physics trains of bunches with separation of 150 ns
- 368 bunches
- Started commissioning 50 ns bunch spacing
- But this was limited by electron cloud effects
- Transition to Heavy Ions First Collisions: Nov. 7

8000 Scientists and Engineers, 400 Institutions,1700 from ~94 Universities and Labs in the the US

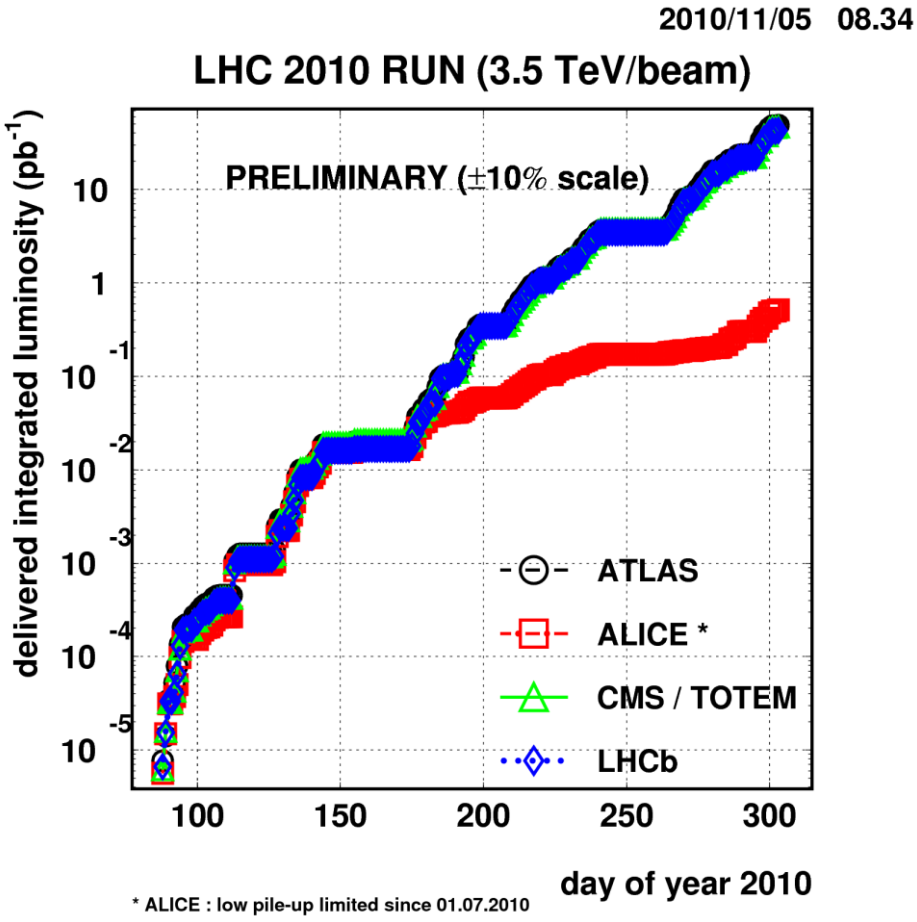
The U.S. is ~24% of the LHC Experiments

	Total Number of Collaborators	U.S. Collaborators	# of U.S. Institutions	# Graduate Students
ALICE	1287	73	12	23
ATLAS	2983	700	44	169
CMS	2160	930	49	200
LHCb	733	17	1	5
TOTEM	100	2	1	
Total	7263	1722	94	397
		24%		

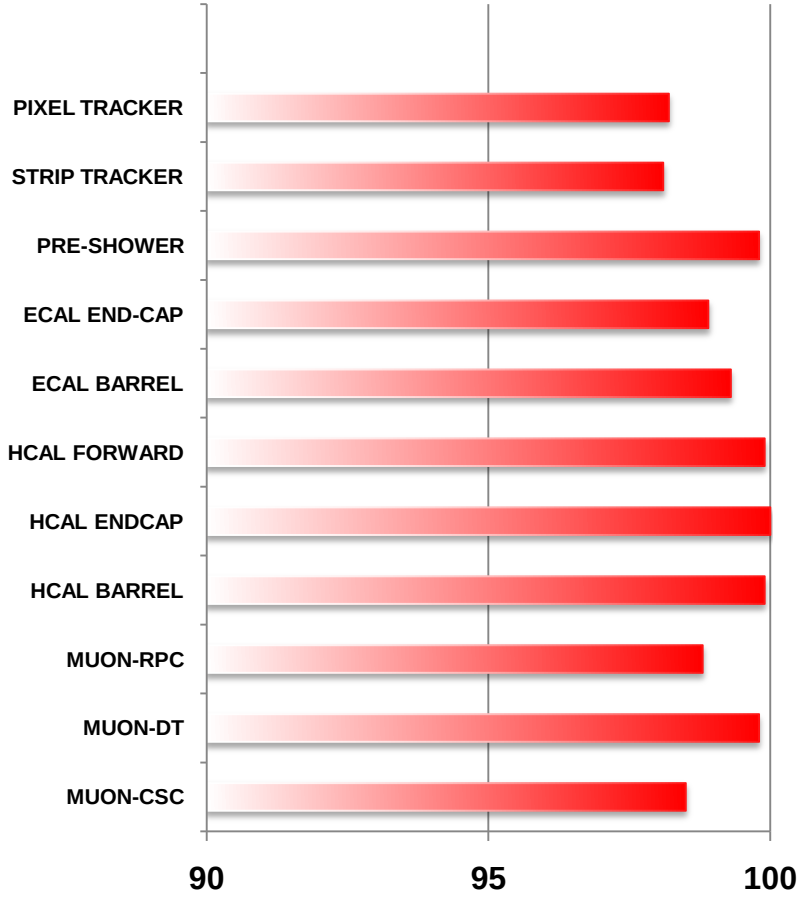
ATLAS p-p Collisions @ 7 TeV



Integrated Luminosity for All Experiments



CMS General Status



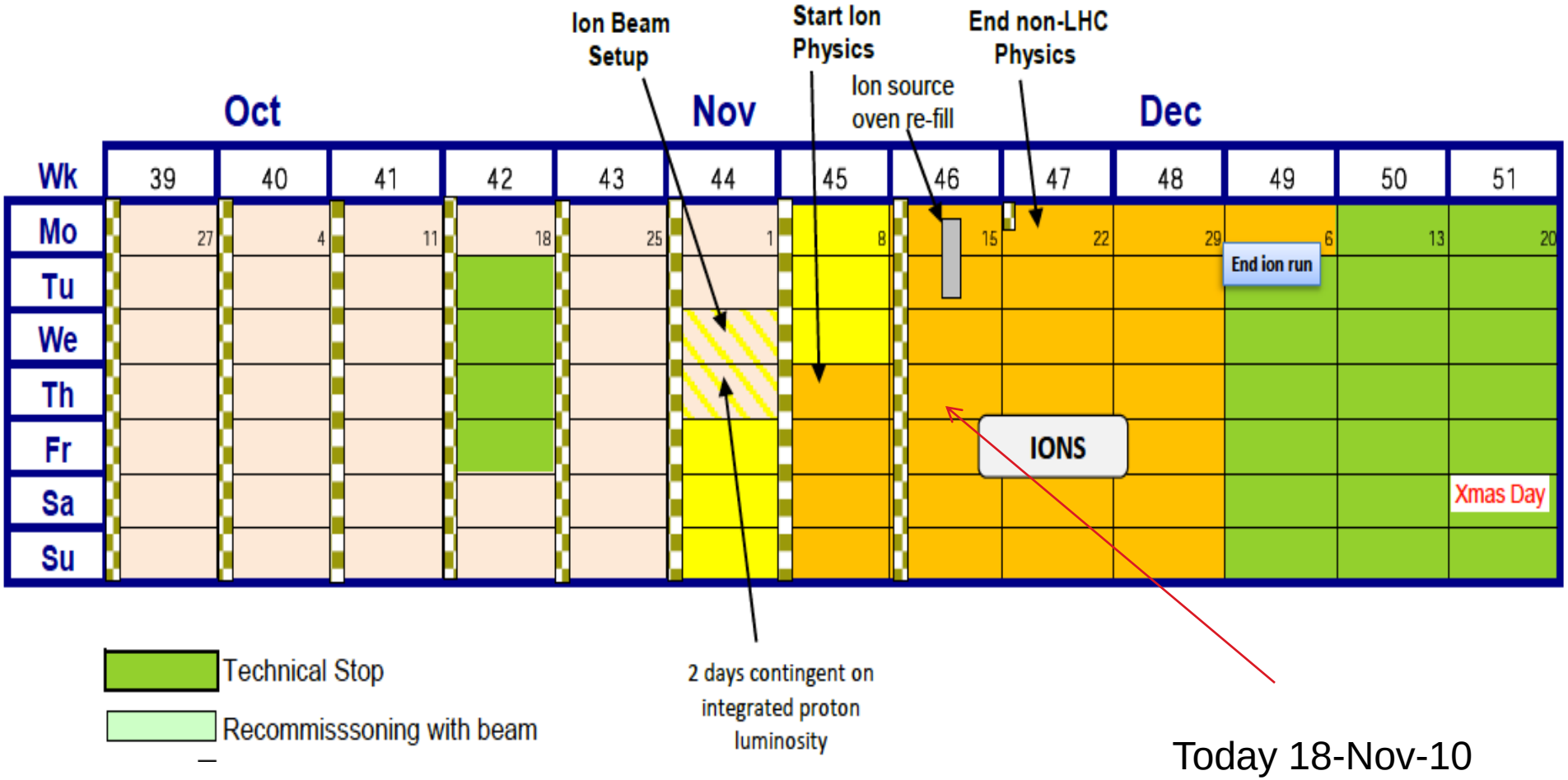
- Shutdown Plan
  - End of 2010 Run: late on 06 Dec
  - Magnet ramp down: early on 07 Dec
  - Services stop: 09 Dec
  - Partial services restored: 07 Jan
  - Full services restored: 21 Jan
  - Beam Pipe pump-down start: 28 Jan
  - Magnetic field tests: 07 Feb
  - Magnetic field on: 08 Feb
  - End of shutdown: 18 Feb
- CMS main tasks
  - Install TOTEM T1 +Z and –Z
  - Upgrade cooling power for filter farm for processors to achieve full 100K rate
  - Annual cooling system maintenance

•Delivered 47 pb^{-1}, recorded 43 pb^{-1} Overall data taking efficiency 92%
~85% usable by all analyses.
•Heavy Ions: delivered ~ 1.96 μb^{-1}, efficiency > 95%

ATLAS General Status

- Detector Operation
  - Reasonably efficient & clean at L ~ $2x10^{32}$
    - Optical links continue to be a worry in Silicon and LAr Systems
    - Higher than expected background in Pixels (Vacuum problem)
    - More HV trips in TRT, LAr, TileCal, Muons (TGC) at higher luminosity
- Planning for Winter Shutdown underway
  - Open two sides: shutdown 11 wks
    - Si (Optical transmitter spectrum measurements)
    - LAr (Optical transmitter replacements)
    - TileCal (Low voltage power supply & Drawer repair, Prototype LVPS installation)
    - Muons (alignment bar replacements, some alignment bar installation)

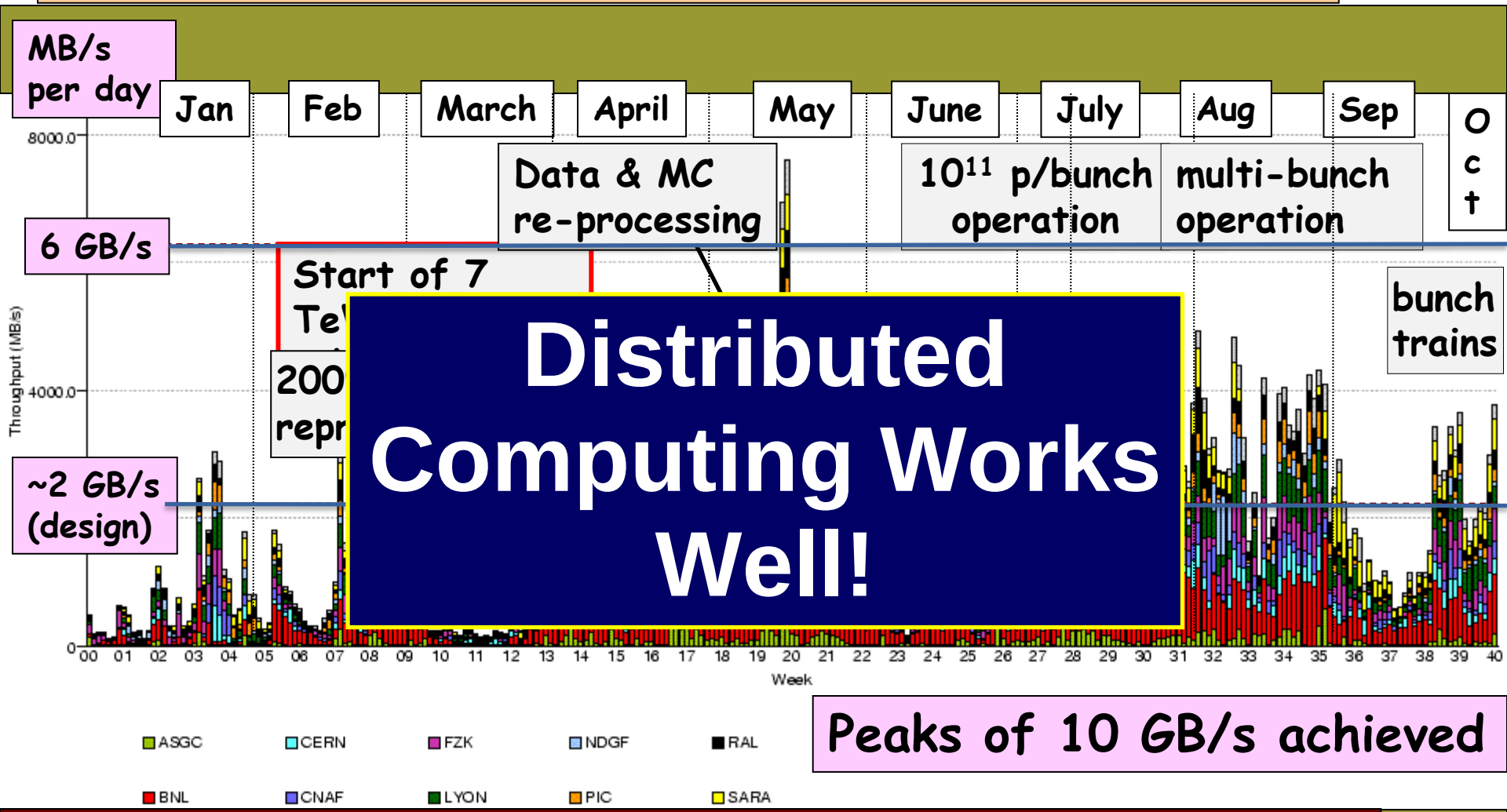
Short Term Schedule



Today 18-Nov-10

Worldwide data distribution and analysis (F.Gianotti)

Total throughput of ATLAS data through the Grid: 1st January → Mid-Oct.



Peaks of 10 GB/s achieved

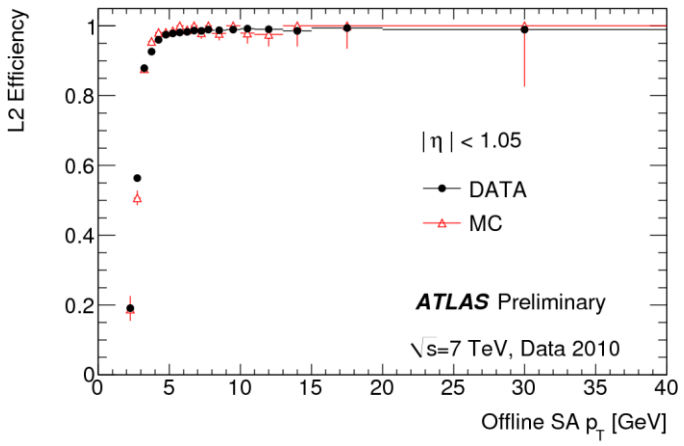
Grid-based analysis in Summer 2010: >1000 different users; >15M analysis jobs

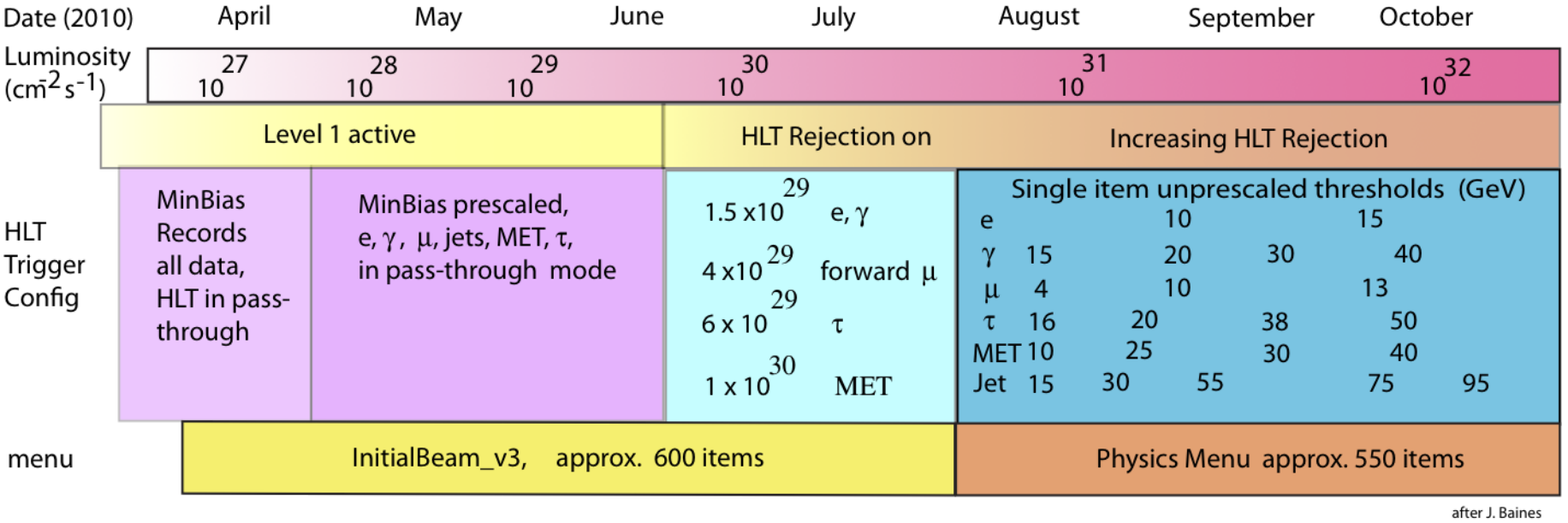
The excellent Grid performance has been crucial for fast release of physics results.
E.g.: ICHEP: the full data sample taken until Monday was shown at the conference Friday

ATLAS Trigger evolution

- Five orders of magnitude increase in luminosity
- Gradually commission and then apply HLT rejection
- Evolution of HLT configuration during the pp run:

- One of many examples: check effic of L2 4GeV p_T muon selection





after J. Baines

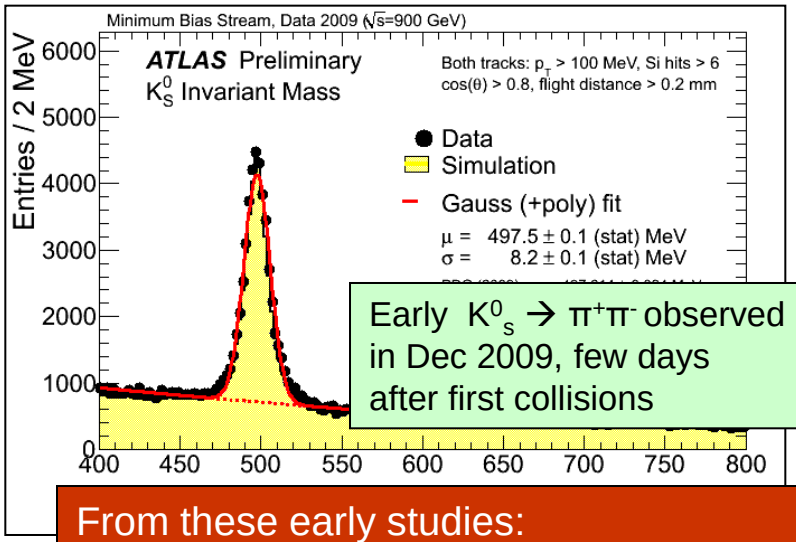
Physics in 2009-10 and Prospects for 2010-11

- Goals for 1-10pb^{-1}: Fall 2009 – Summer 2010: *Achieved*
  - **Understanding/optimizing detector *performance* in depth: tracking, vertexing, calorimetry, muons, jet reco. & energy scale, b-tagging**
  - **Detector & trigger shakedown; calibration; coping with rising $\mathbf{L}$**
  - **Efficient data-taking; worldwide data processing & analysis**
  - **Understanding the QCD and Electroweak backgrounds**
  - **Observing QCD (and resonant) soft physics in a new energy regime**
  - **Rediscovery of the SM at 7 TeV: W, Z, Quarkonia, Top; V + N-Jets**
  - **The first New Physics Searches: Q*, Dijet Resonances, Compositeness**
- Major goals for ~45 pb^{-1} (Fall – Winter 2010)
  - **More precise measurements of SM at 7 TeV**
  - **Study of top pair production at 7 TeV**
  - **Search for early SUSY (or alternative) signals**
  - **TeV Resonances: Z', Boosted Tops, RS Gravitons, etc.**
  - **Lay the foundation for early Higgs searches in 2011**

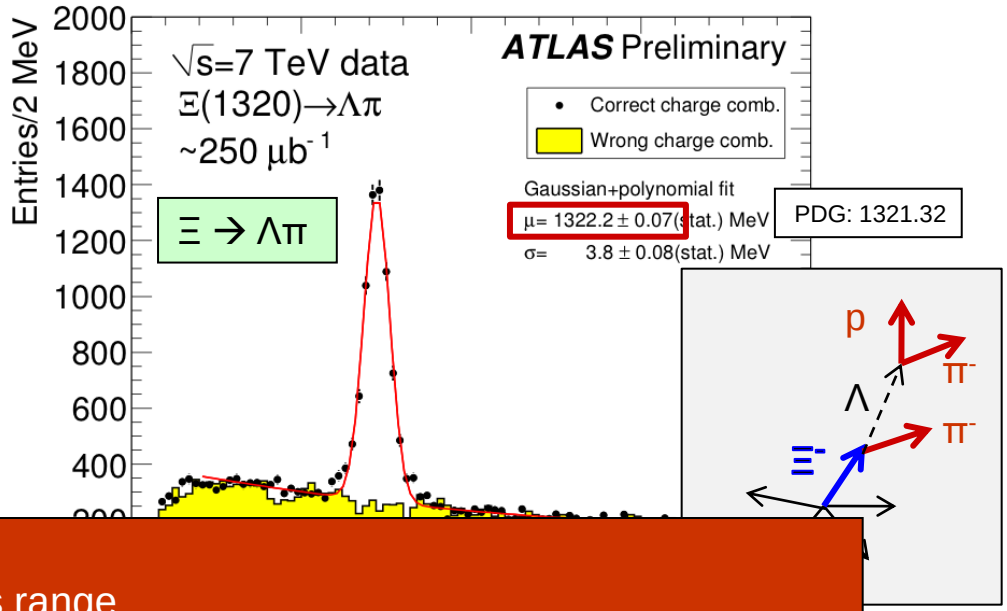
Some highlights of detector performance

- Tracking
- Inner detector material mapping
- b-tagging
- Muon trigger and reconstruction
- EM calorimeter energy scale and resolution
- Jet energy scale
- Photon identification
- Missing E_T performance
- τ identification working

ATLAS Inner Detector: early observation of peaks and cascade decays …



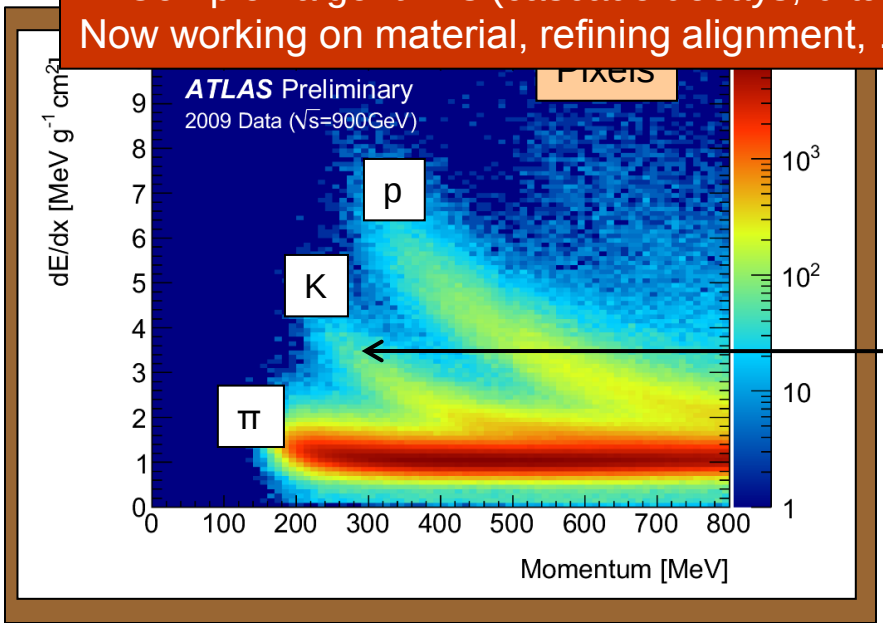
Early $K^0_S \rightarrow \pi^+\pi^-$ observed in Dec 2009, few days after first collisions

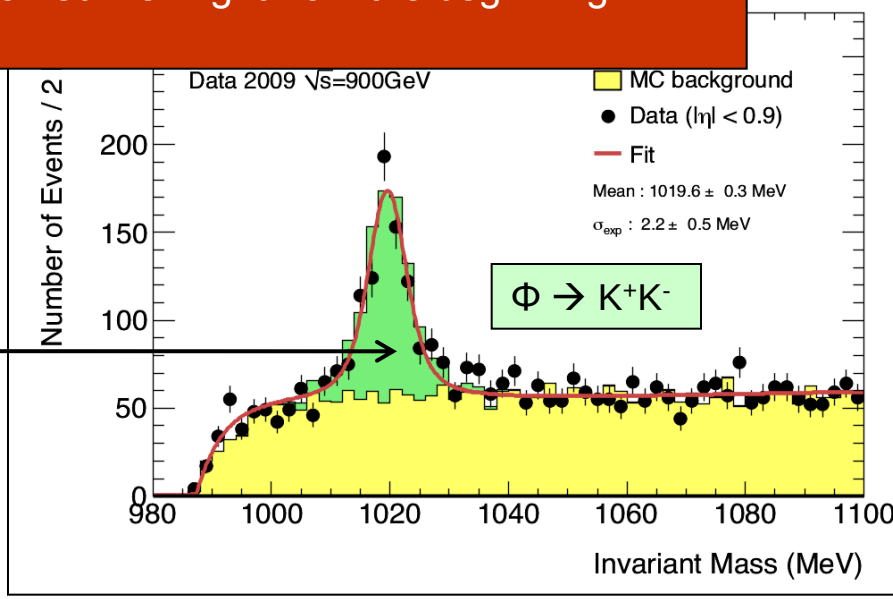


From these early studies:

- ❑ Momentum scale known to few permil in this range
- ❑ Resolution as expected (dominated by multiple scattering)
- ❑ Complex algorithms (cascade decays, b-tag, …) worked well right from the beginning

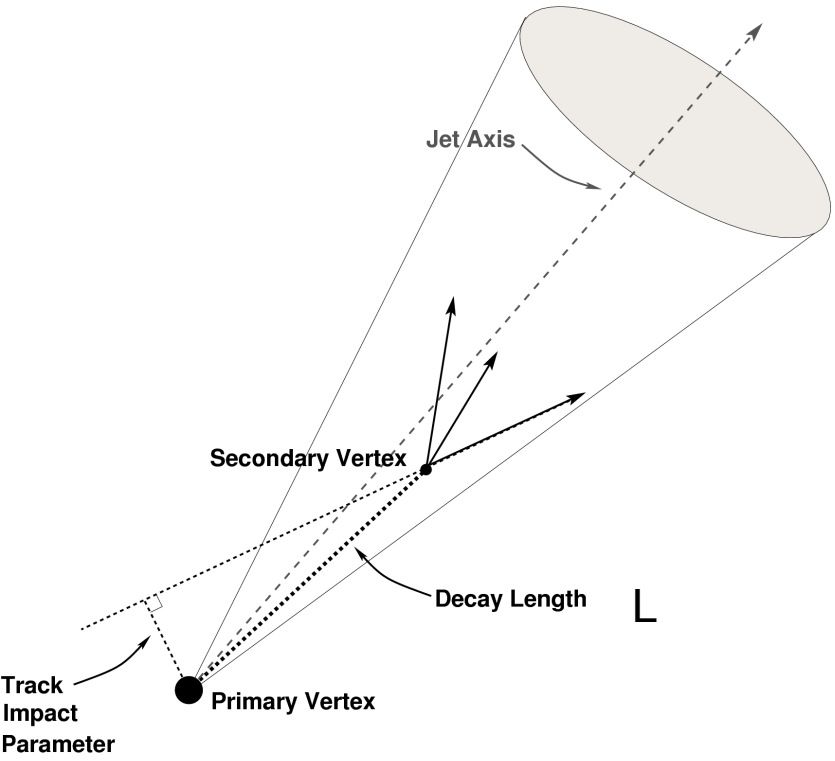
Now working on material, refining alignment, …

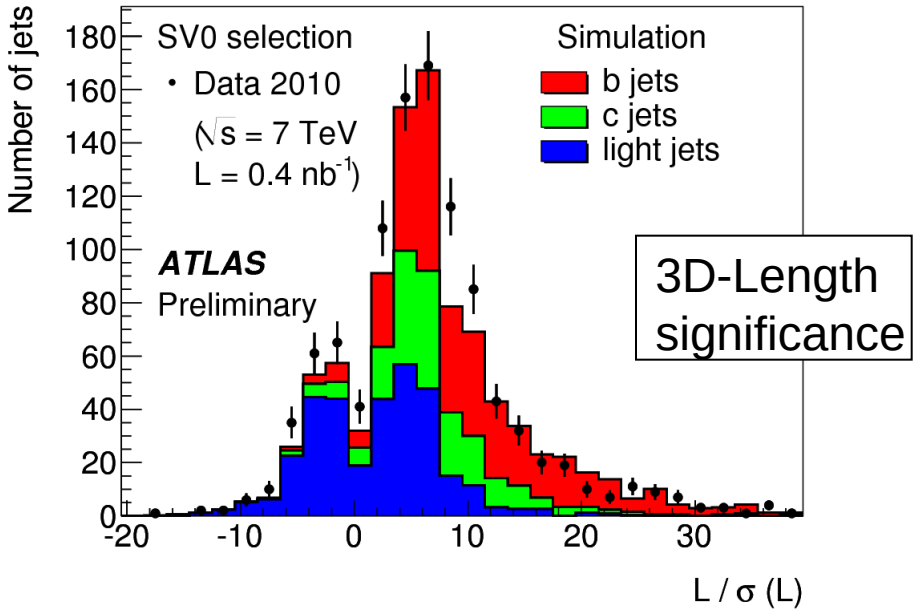




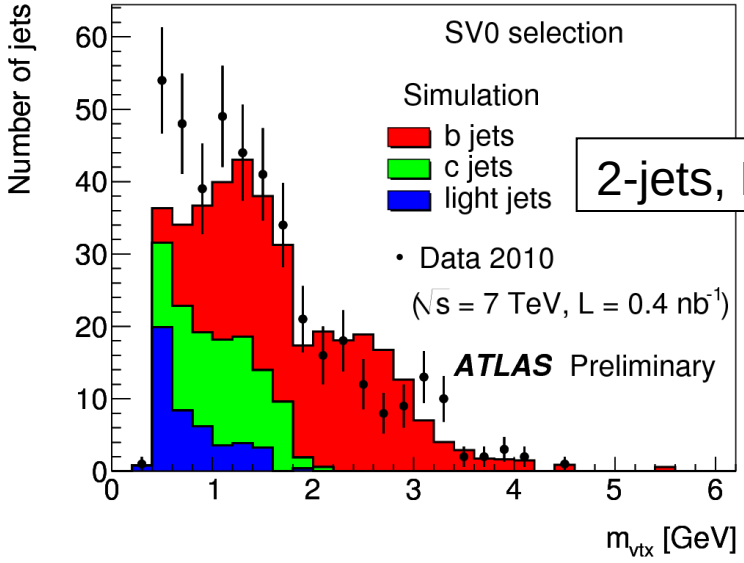
B-tagging

Example of the SV0 algorithm





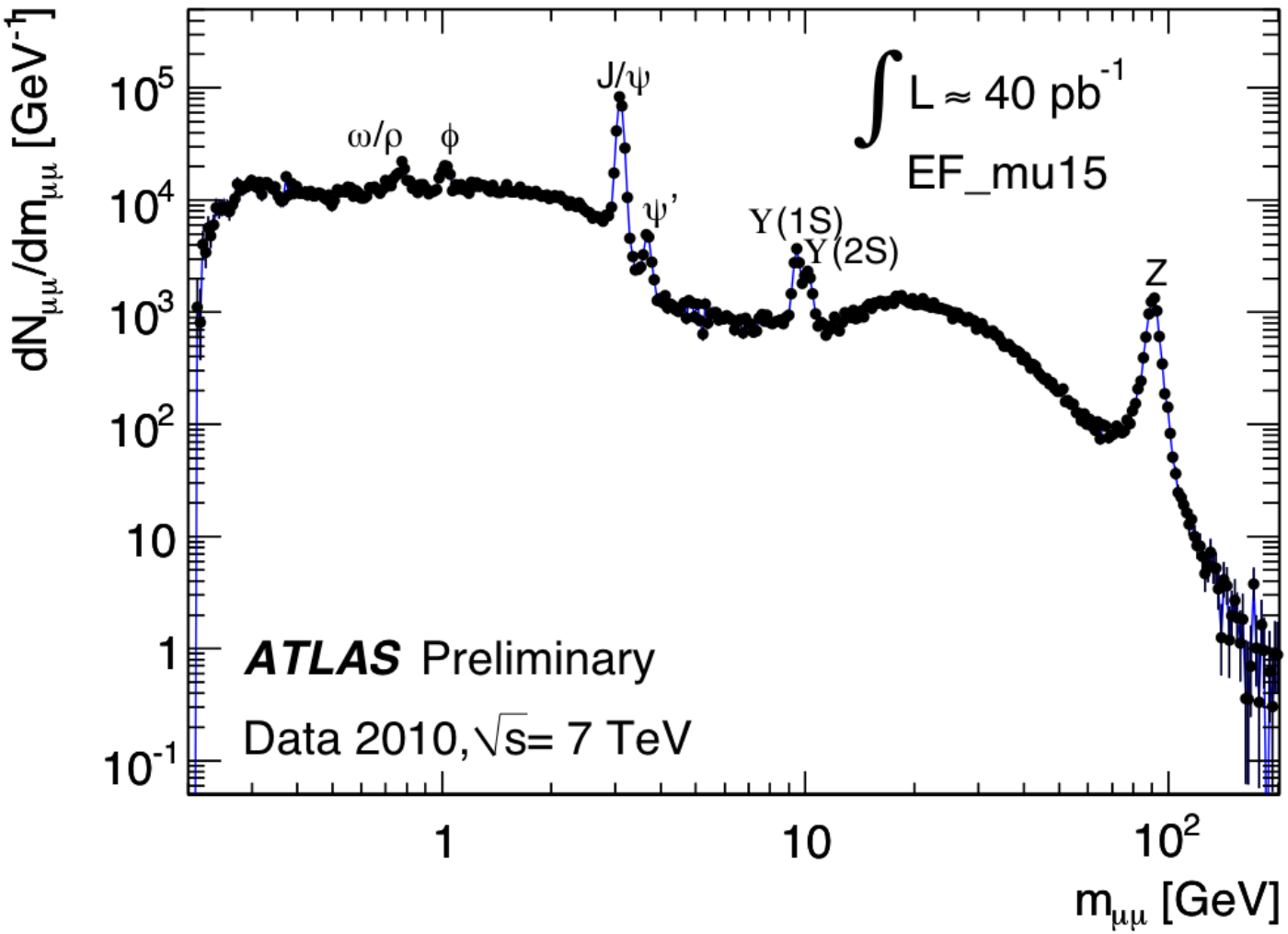
3D-Length significance



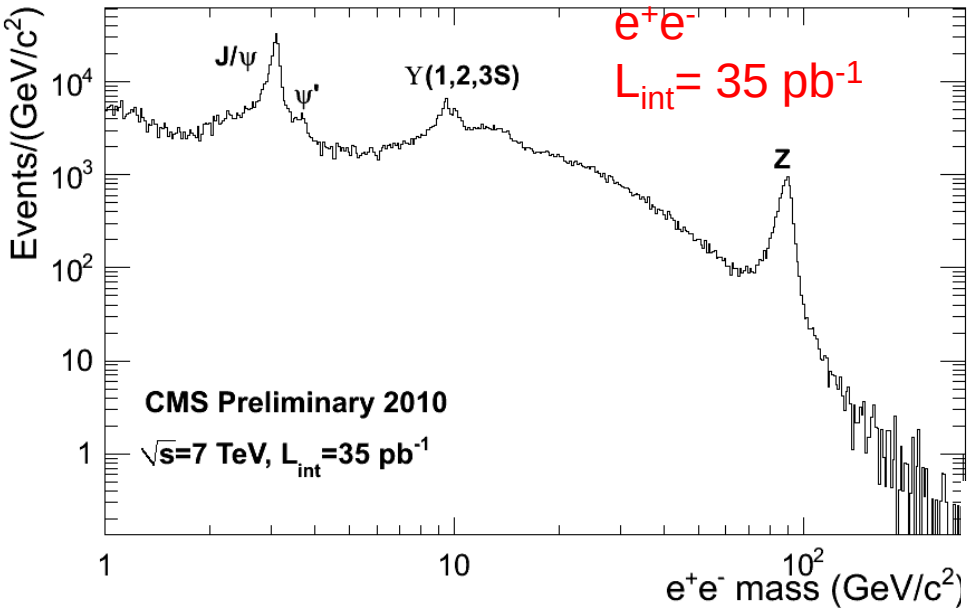
2-jets, L/σ > 7

ATLAS: Di-muon invariant mass

- Leading muon, p_T>15 GeV, second muon,



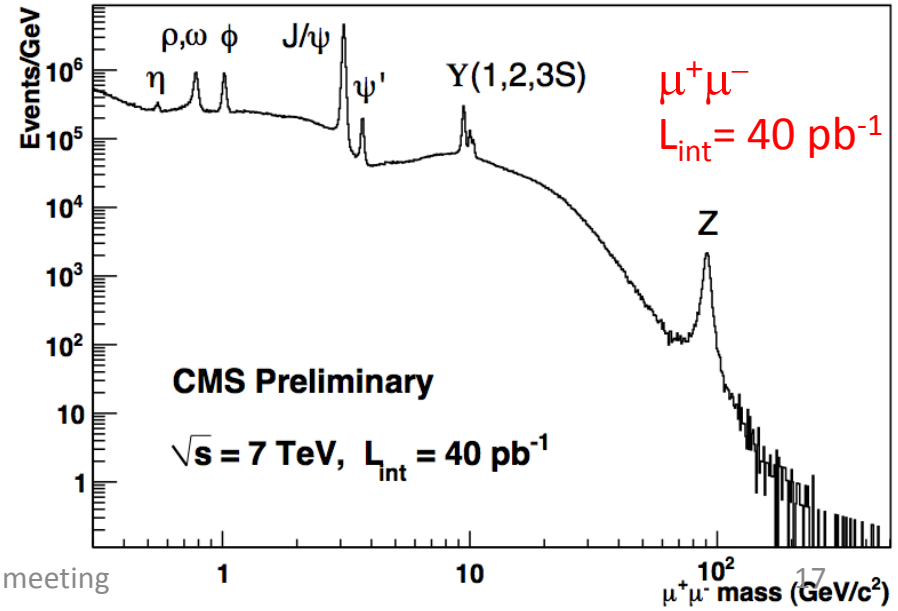
CMS Di-lepton Invariant mass distributions



A tribute to Level1 and HLT trigger capability and flexibility

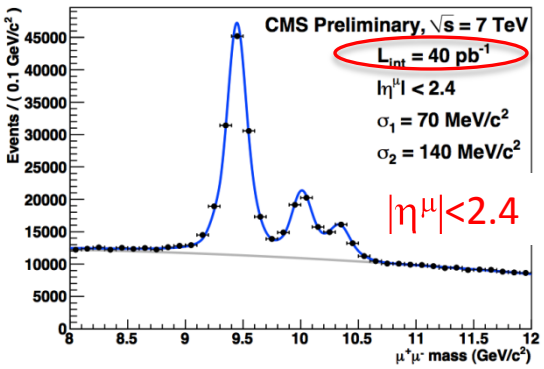
e^+e^- widths:
J/Ψ 52 MeV
Υ 149 MeV

$\mu^+\mu^-$ widths:
J/Ψ 30 MeV
Υ 67 MeV

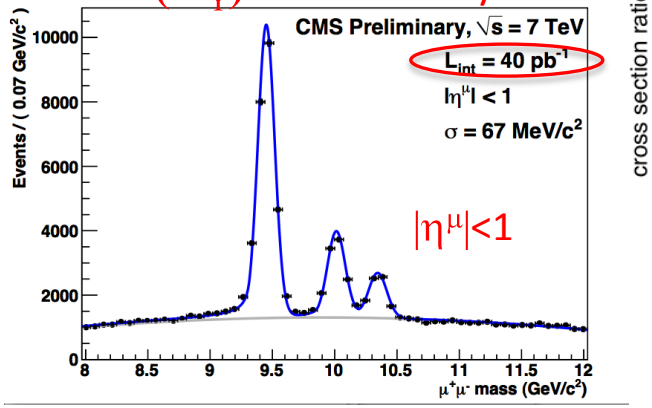


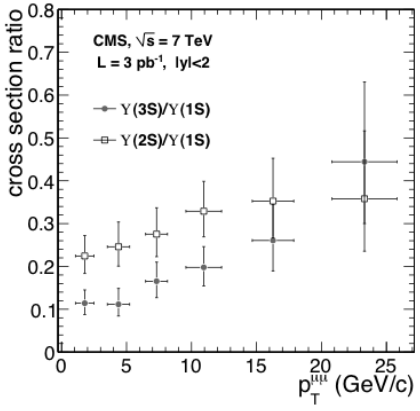
CMS Υ production

$\sigma(m_\Upsilon)$= 70 2 MeV/c^2



$\sigma(m_\Upsilon)$= 67 2 MeV/c^2





σ Ratios
$|Y^Y|$<2

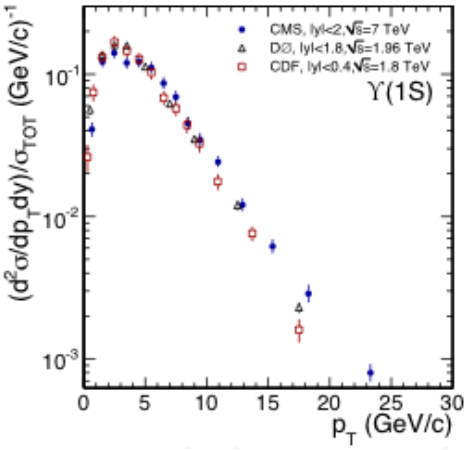
Unpolarized production assumption

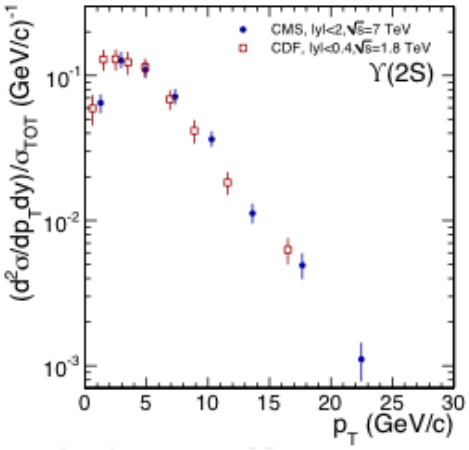
$$\sigma(pp \to \Upsilon(1S)X) \cdot \mathcal{B}(\Upsilon(1S) \to \mu^+\mu^-) = (7.49 \pm 0.13(\text{stat.})^{+0.67}_{-0.49}(\text{syst.}) \pm 0.82(\text{lumi.}))\ \text{nb},$$

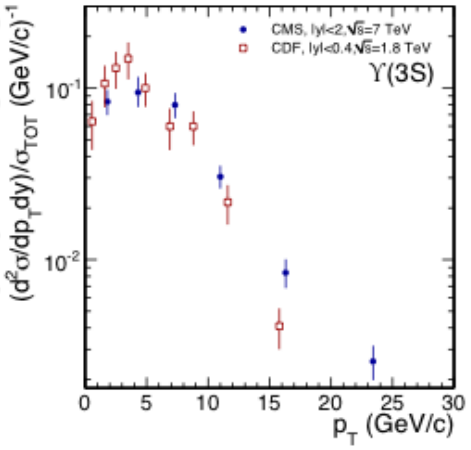
$$\sigma(pp \to \Upsilon(2S)X) \cdot \mathcal{B}(\Upsilon(2S) \to \mu^+\mu^-) = (1.93 \pm 0.08(\text{stat.})^{+0.19}_{-0.14}(\text{syst.}) \pm 0.21(\text{lumi.}))\ \text{nb},$$

$$\sigma(pp \to \Upsilon(3S)X) \cdot \mathcal{B}(\Upsilon(3S) \to \mu^+\mu^-) = (1.04 \pm 0.07(\text{stat.})^{+0.12}_{-0.09}(\text{syst.}) \pm 0.11(\text{lumi.}))\ \text{nb}.$$

CMS vs CDF & D0



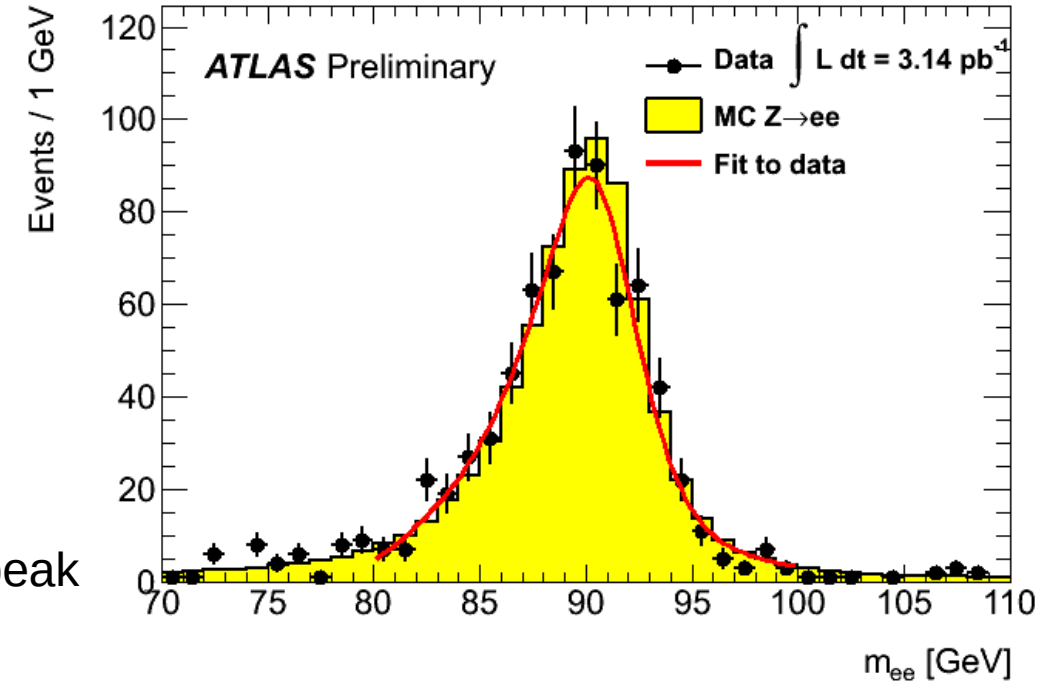




Electron ID and E-scale

Electron reconstruction and ID:
-energy from calibrated cluster
-angles from track
3 levels of electron ID:
-loose(rough shower shape and track)
-medium: ref shower shape, pixel hit,a0
-tight: track match, TRT, E/P
Tight (>20 GeV)rejection/jets up to 10^5

2 "medium" electrons →clean Z^0 peak



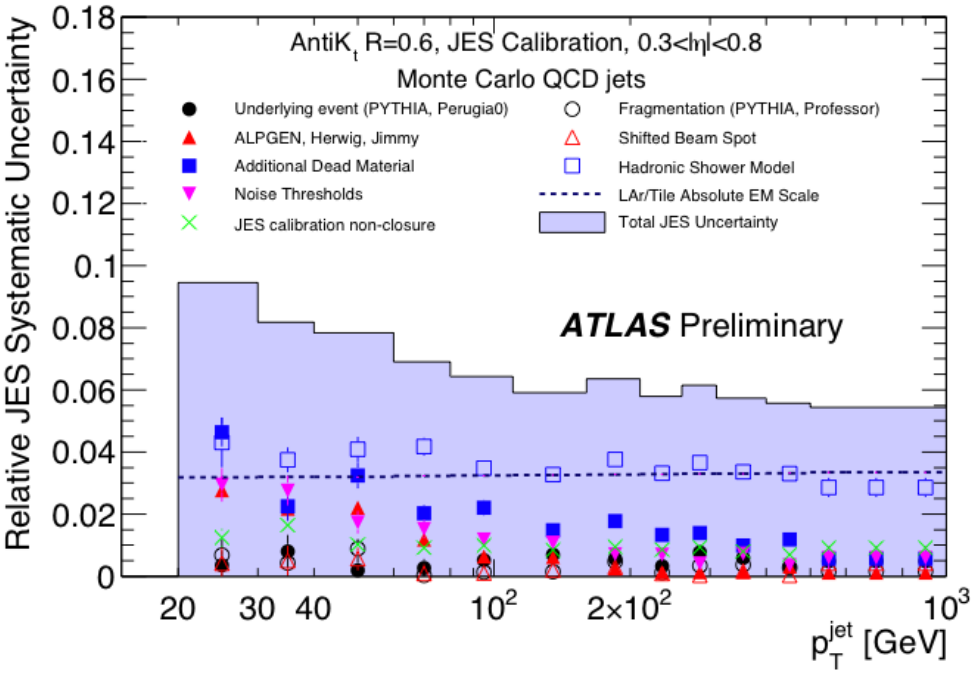
Intercalibration:
- initial E-scale transported from test-beam with MC
- Checked (to ~2%) with pizero
-fit with Z mass constraint : barrel low by 0.97+-0.16%,EC high by 2.07 % and 1.70+-0.5%

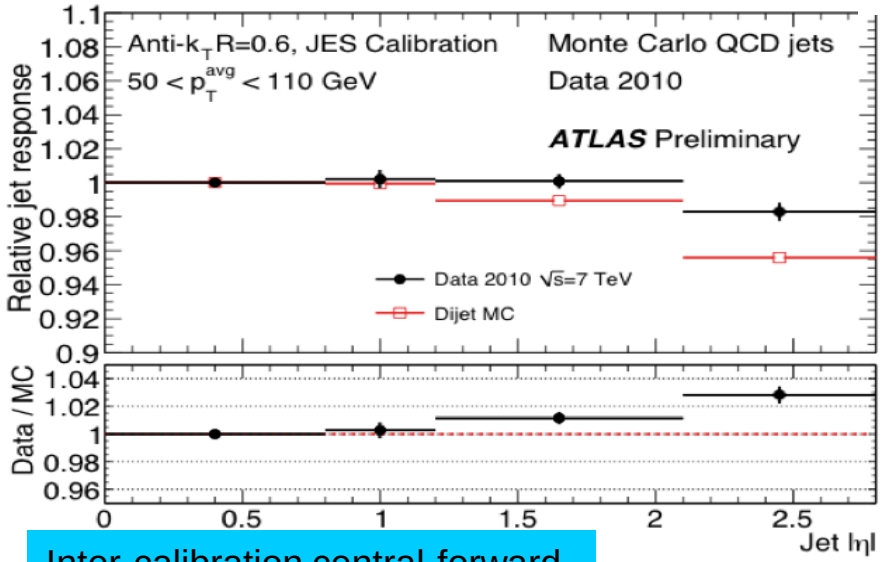
Resolution:
-after rescale: fit to line shape (Breit-Wigner+ crystal ball convoluted with Gaussian)
σ (data) = 1.59+-0.04 GeV σ (MC,w/o constant term)= 1.40+-0.01 GeV

Jet Energy Scale

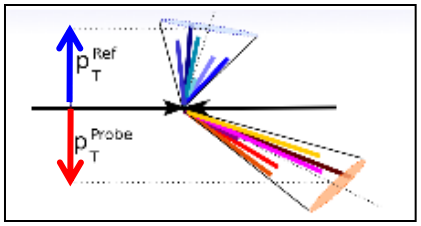
- Jet reconstructed from "topological clusters"
- Jet momenta corrected for
  - -calorimeter non-compensation
  - -dead material, etc.

  using η/p_T-dependent calibration factors derived from MC (tuned with "combined testbeam" data)
- Result checked with single particles /Min bias





Inter-calibration central-forward checked using jet p_T-balance

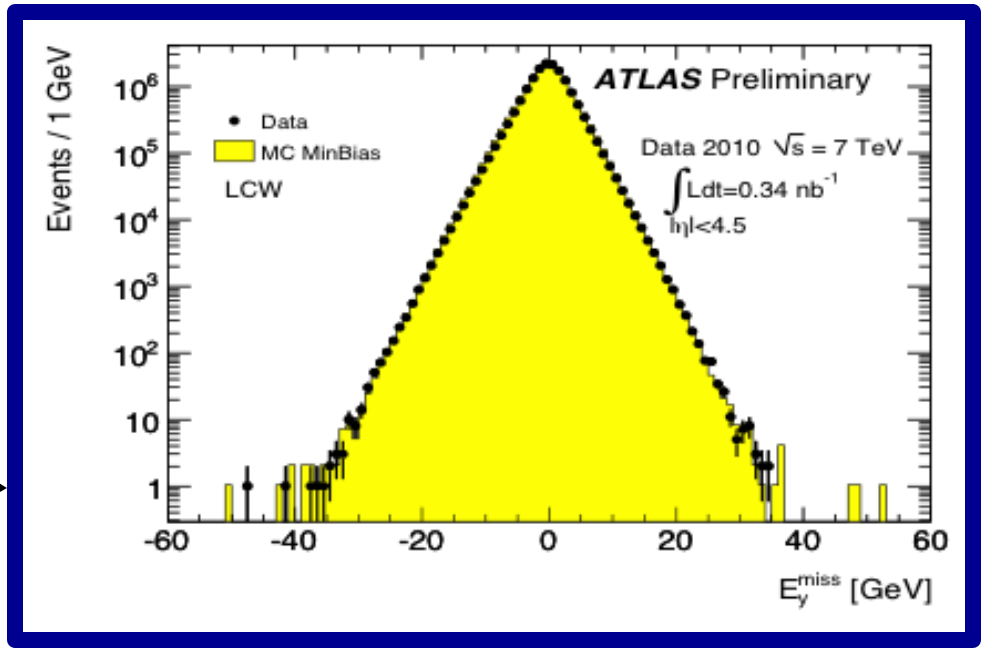


Today JES known to : ~ 7%

Ultimate goal: ~1%

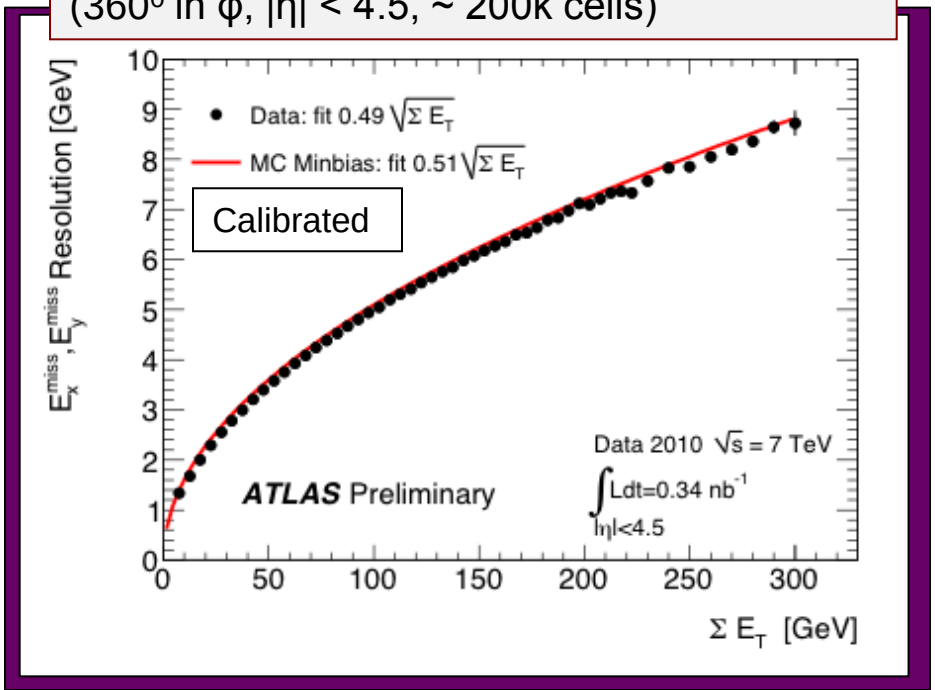
Missing transverse energy in the calorimeters

Calibrated E_T^{miss} from minimum-bias events (component on vertical axis)



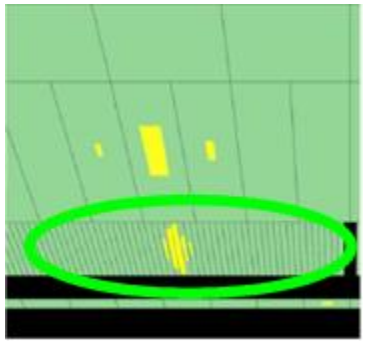
Sensitive to calorimeter performance (noise, coherent noise, dead cells, mis-calibrations, cracks, etc.), and cosmics and beam-related backgrounds ("Event cleaning")

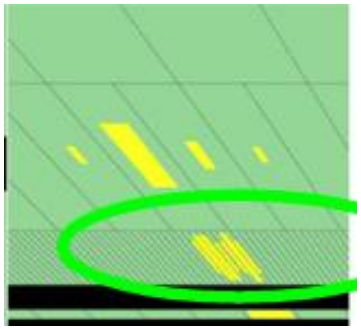
Measured over ~ full calorimeter coverage (360^0 in φ, |η| < 4.5, ~ 200k cells)

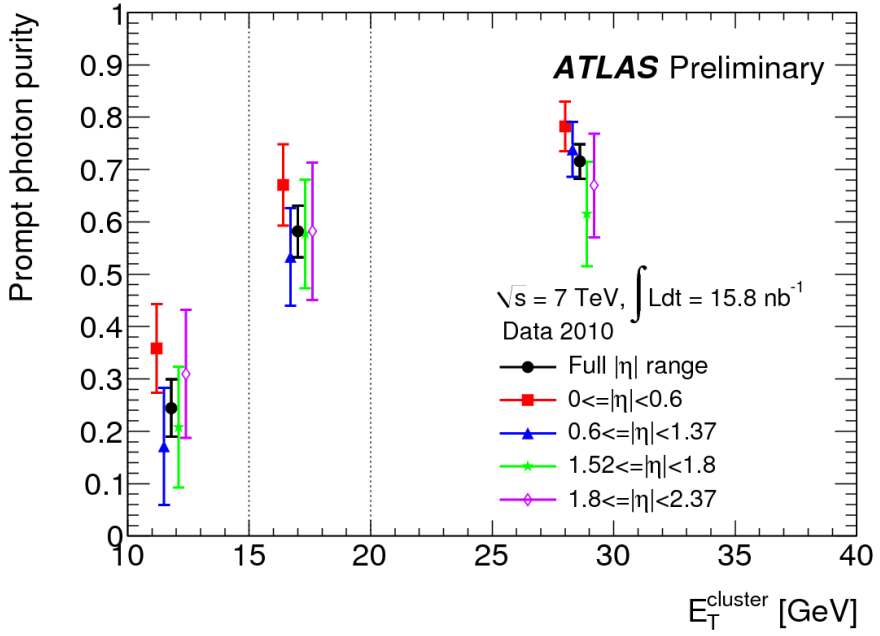


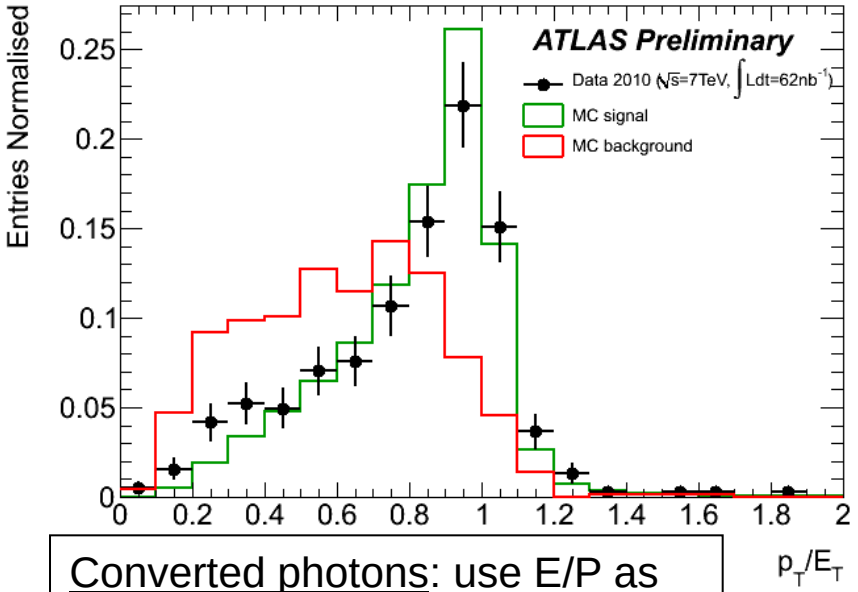
Direct Photons : purity of ~70% above 20 GeV

- Tight selection: rely heavily on shower structure in strip section (double peak, width,energy fraction,..
- Jet rejection (leading π^0) less effective than for electrons(
- Completed by isolation







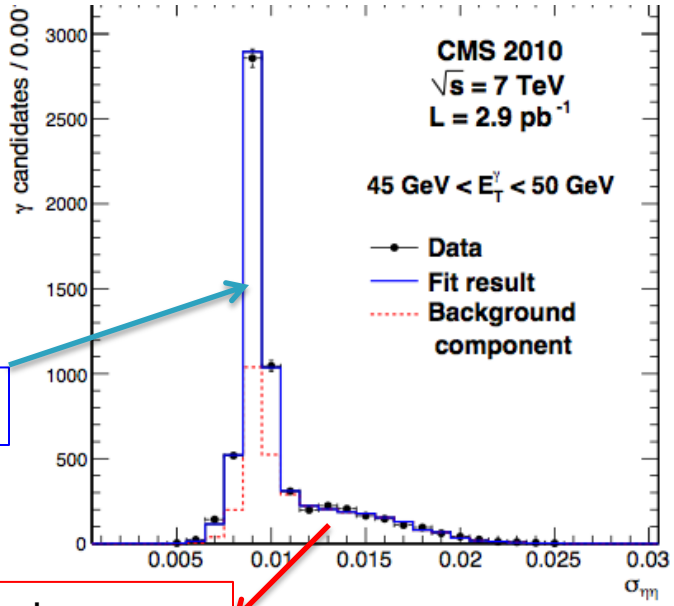


Converted photons: use E/P as a complementary tool

CMS isolated γ production

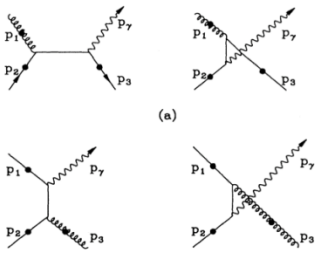
$$\sigma^2_{\eta\eta} = \frac{\sum_{\substack{crystal-i \\ in\,5x5 \\ aroundmx}} \omega_i (\eta_i - \bar{\eta})^2}{\sum_{crystal-i} \omega_i} \qquad \omega_i = \max\left(0, 4.7 + \ln\left(E_i / E_{5x5}\right)\right)$$

Discri variable: $\sigma_{\eta\eta}$

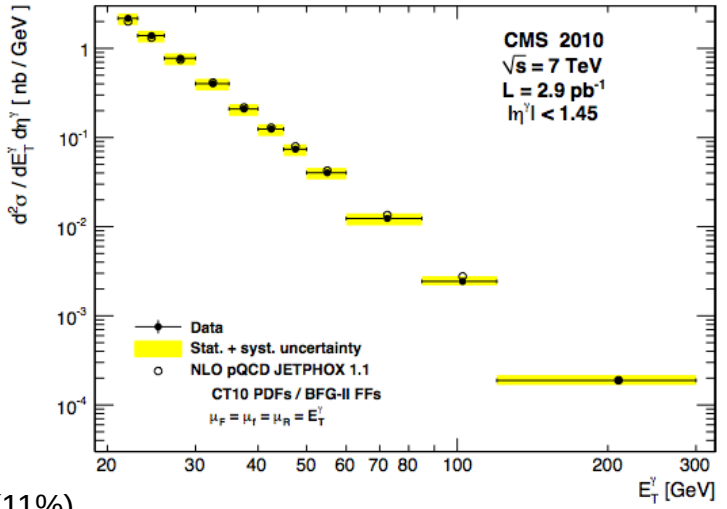


prompt

Bkgnd from decays

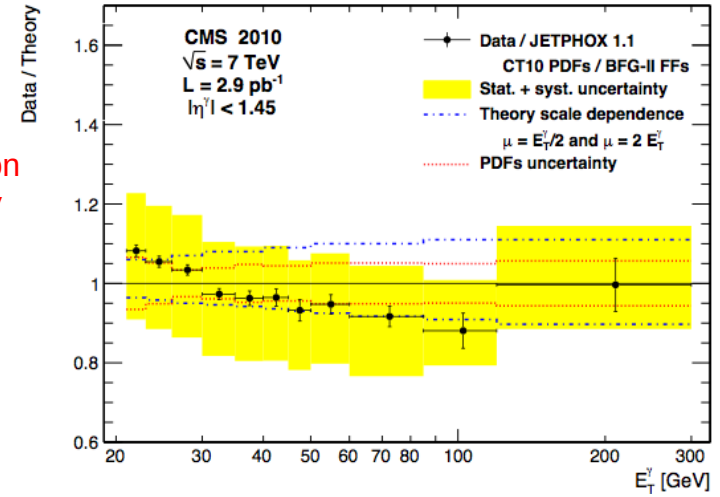


Measurement at higher $Q^2$and lower $x_t=2E_t/\sqrt{s}$ than Tevatron



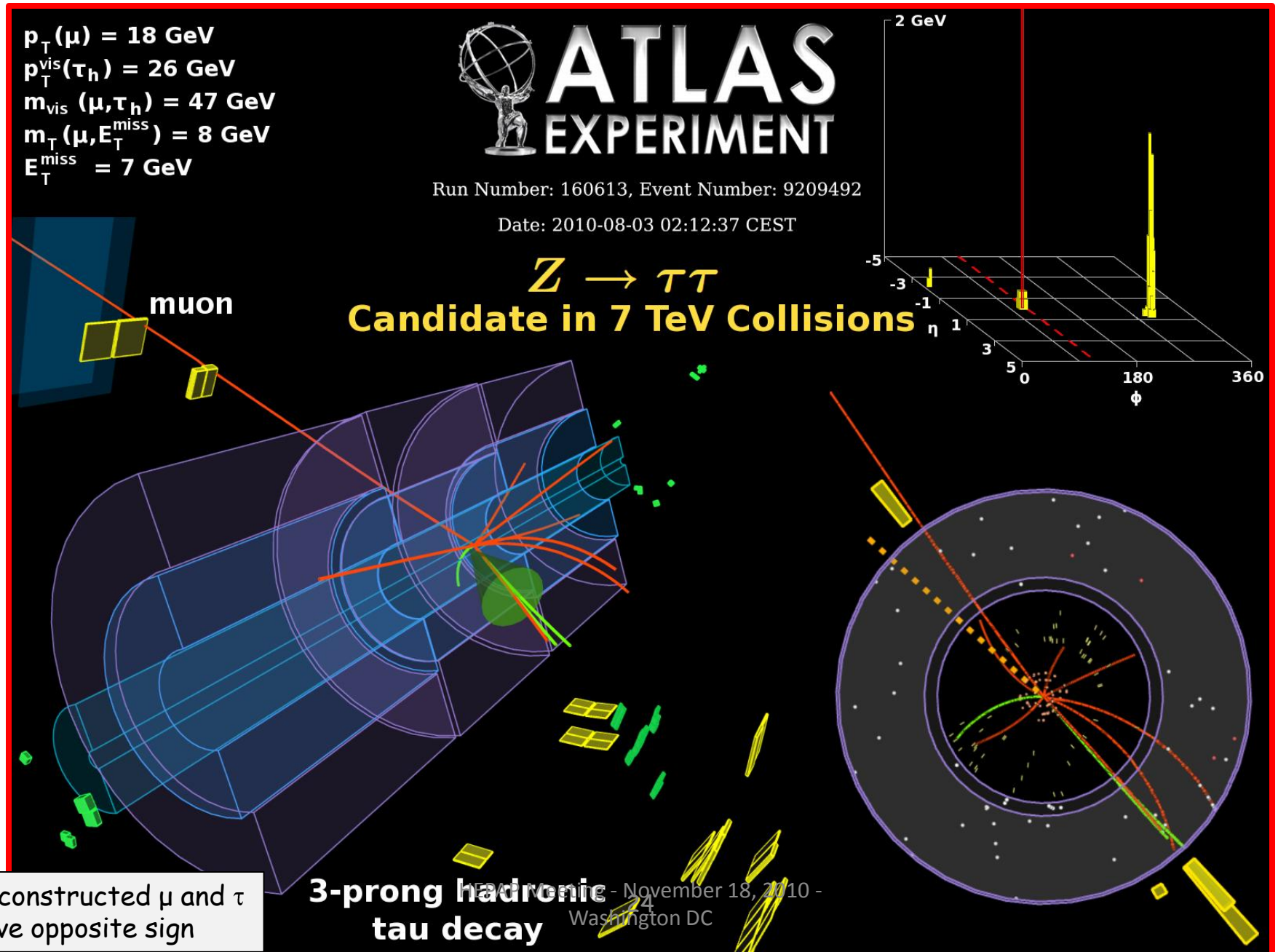
Lumi error (11%) not included

Comparison with theory



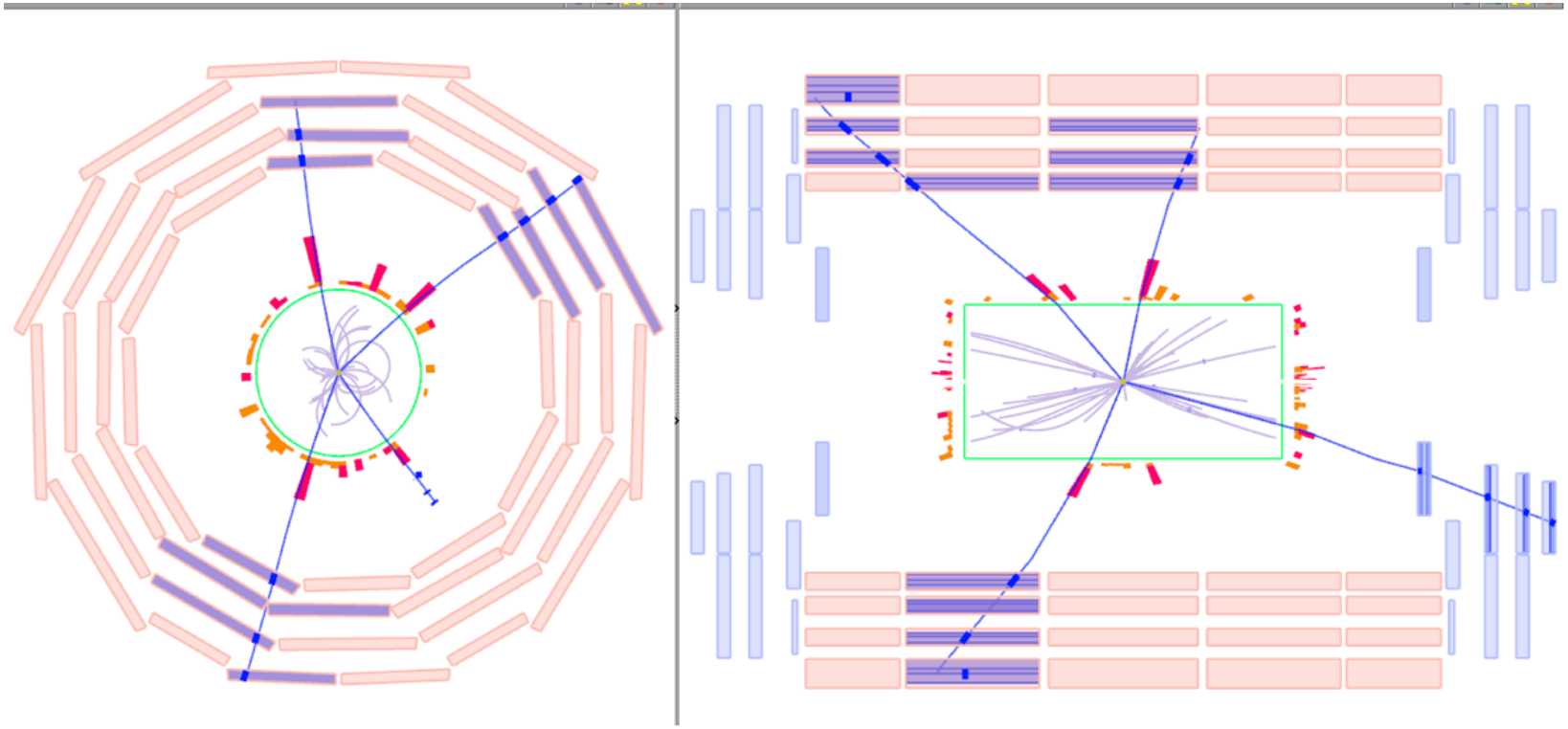
$W \rightarrow \tau\nu$, $Z \rightarrow \tau\tau$

Signals more difficult to observe due to softer (visible) lepton spectrum and larger backgrounds



Reconstructed μ and τ have opposite sign

CMS: A beautiful ZZ event



Masses

: 92.15 GeV (total(Z) p_T 26.5 GeV, ϕ -3.03),
: 92.24 GeV (total(Z) p_T 29.4 GeV, ϕ +.06),
: 70.12 GeV (total p_T 27 GeV),
: 83.1 GeV (total p_T 26.1 GeV).

Invariant Mass of 4μ: 201 GeV

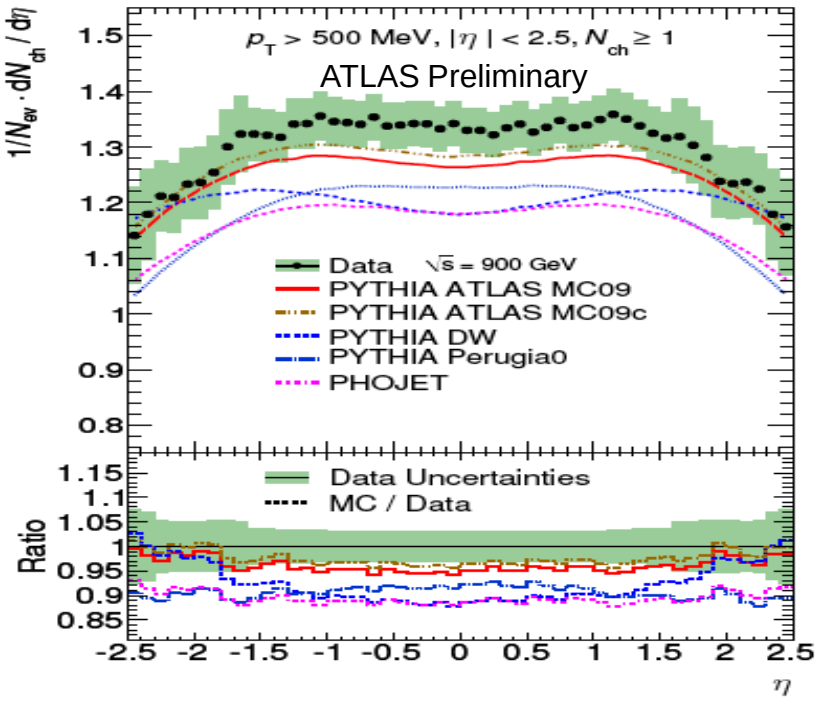
(some) First Physics Results

- Minimum Bias: multiplicity, p_T distributions, underlying event – critical for tuning MC for all backgrounds
- QCD: The Ridge from CMS, jets, search for dijet resonances, search for contact interactions
- W, Z production: background for top and SUSY
- B physics from LHCb (ATLAS and CMS have results too)
- Top production: also background for SUSY
- Higgs sensitivity

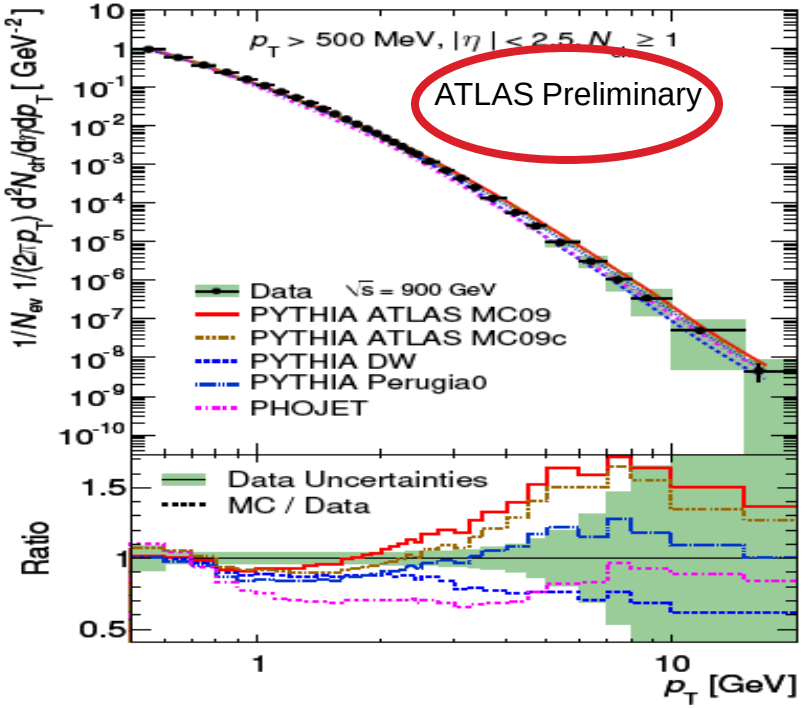
- First Pb Pb results (after ~10 days of collisions)

First Physics – Minimum Bias Distributions shown at March 2010 HEPAP Meeting

- Min Bias trigger (MBTS), primary charged particles $N_{ch} \geq 1$, $|\eta| < 2.5$, $p_T > 500$MeV

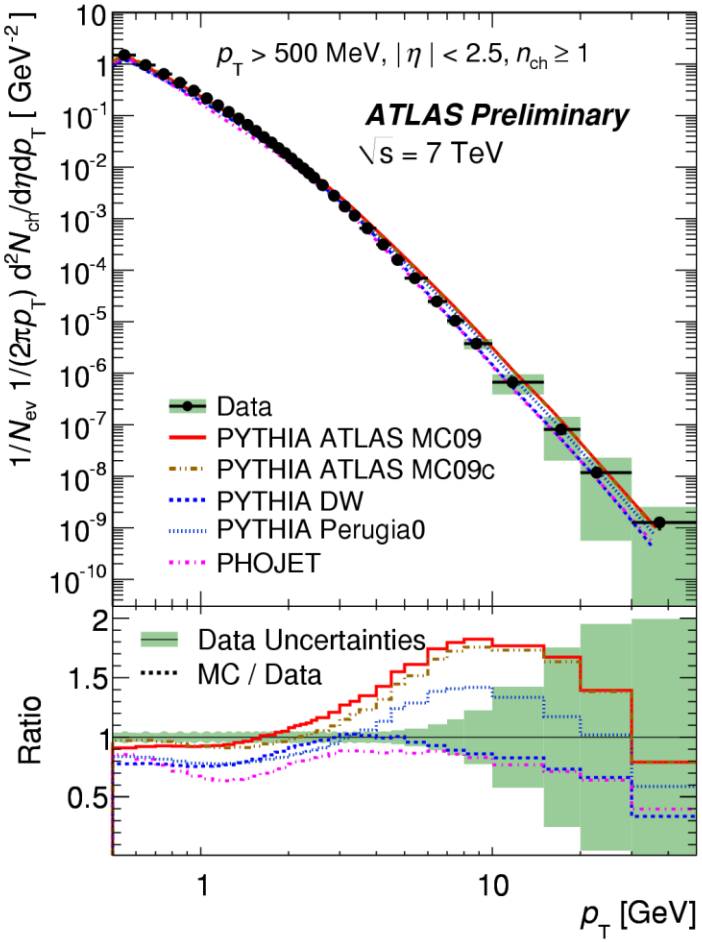


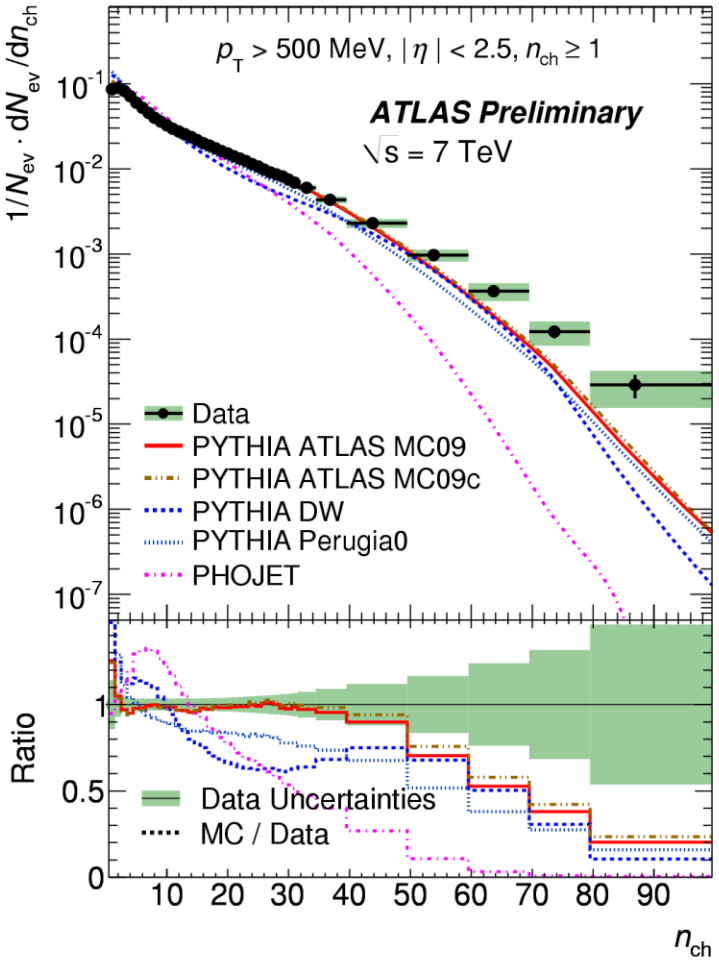
N_{ch} vs η



N_{ch} vs pT

This was followed by 7 TeV running and results





The “ridge”: the first surprising result from LHC

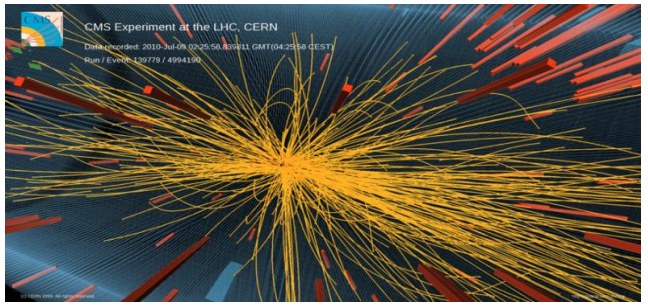
High Energy Physics - Experiment arXiv:1009.4122v1 [hep-ex]

Observation of Long-Range Near-Side Angular Correlations in Proton-Proton Collisions at the LHC

CMS Collaboration

(Submitted on 21 Sep 2010)

JHEP Sep. 27, 2010



MinBias

(b) MinBias, 1.0GeV/c<p_T<3.0GeV/c

high multiplicity (N>110)

(d) N>110, 1.0GeV/c<p_T<3.0GeV/c

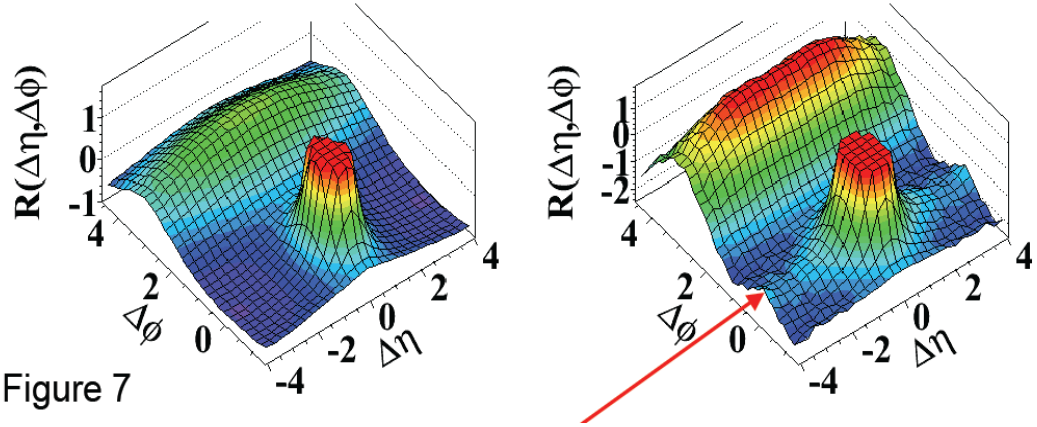
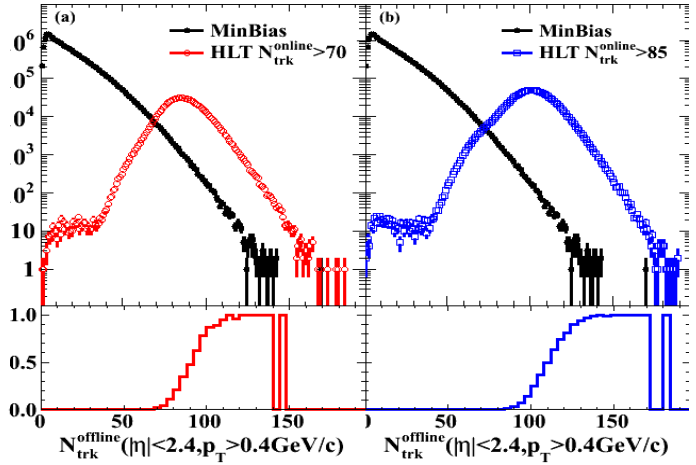


Figure 7



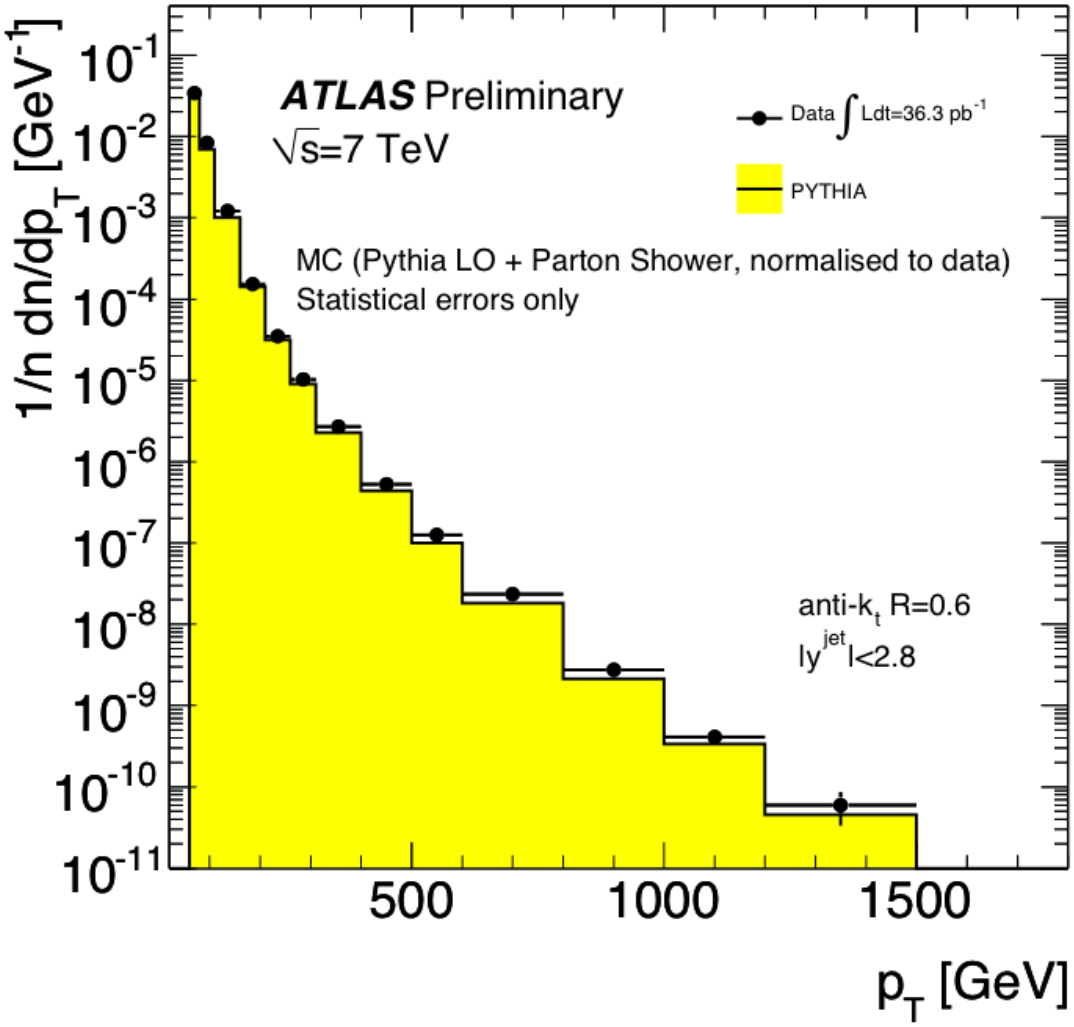
The impact on the scientific community has been sizeable. We are receiving interesting feedback. Several papers on possible interpretations. New set of measurements to understand better the dynamics. There have been meetings with theorists and MC experts.

Inclusive jets

- Combine a range
- of triggers to cover
- the full p_T spectrum

- In all cases, jets
- corrected to
- hadronic scale
- (JES uncertainty 7%)

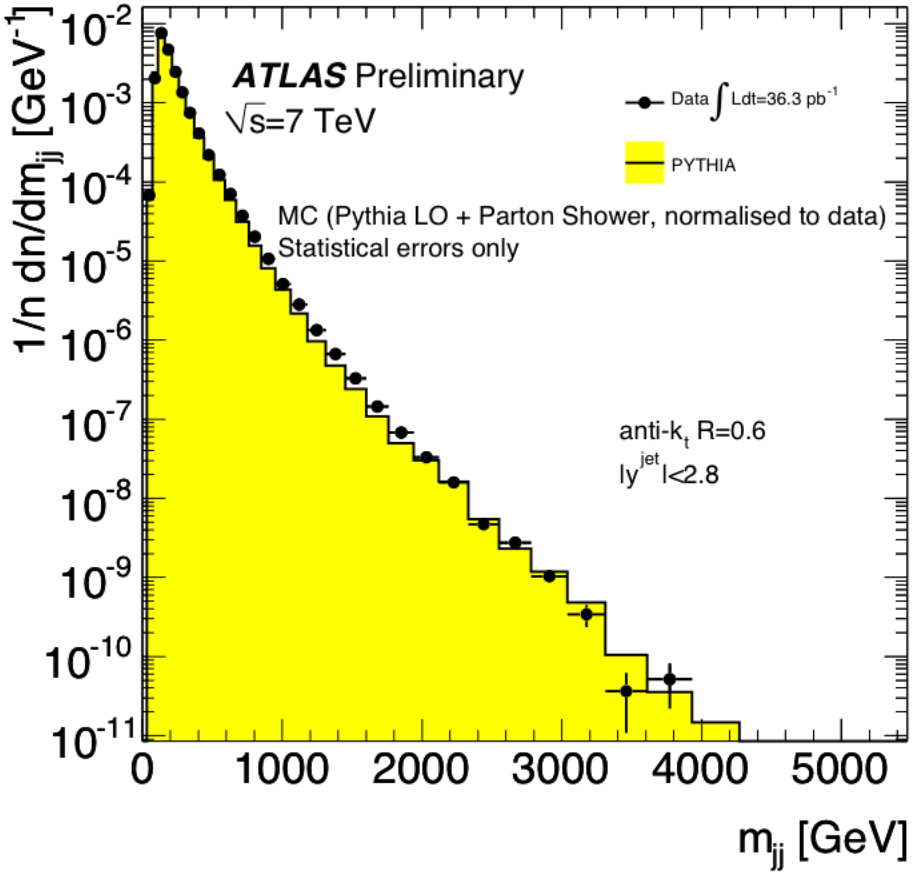
- Jet p_T>60GeV
- Highest p_T jet 1.3 TeV



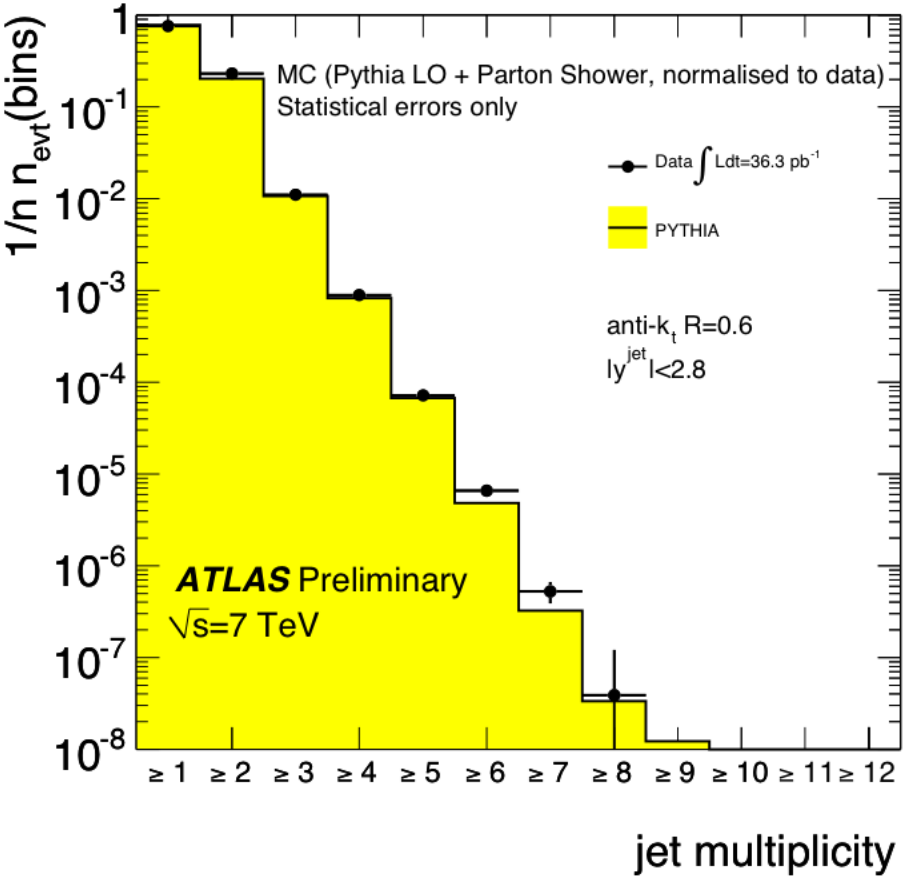
- Shape comparison with MC PYTHIA (LO + parton shower)

Dijets and multi jets

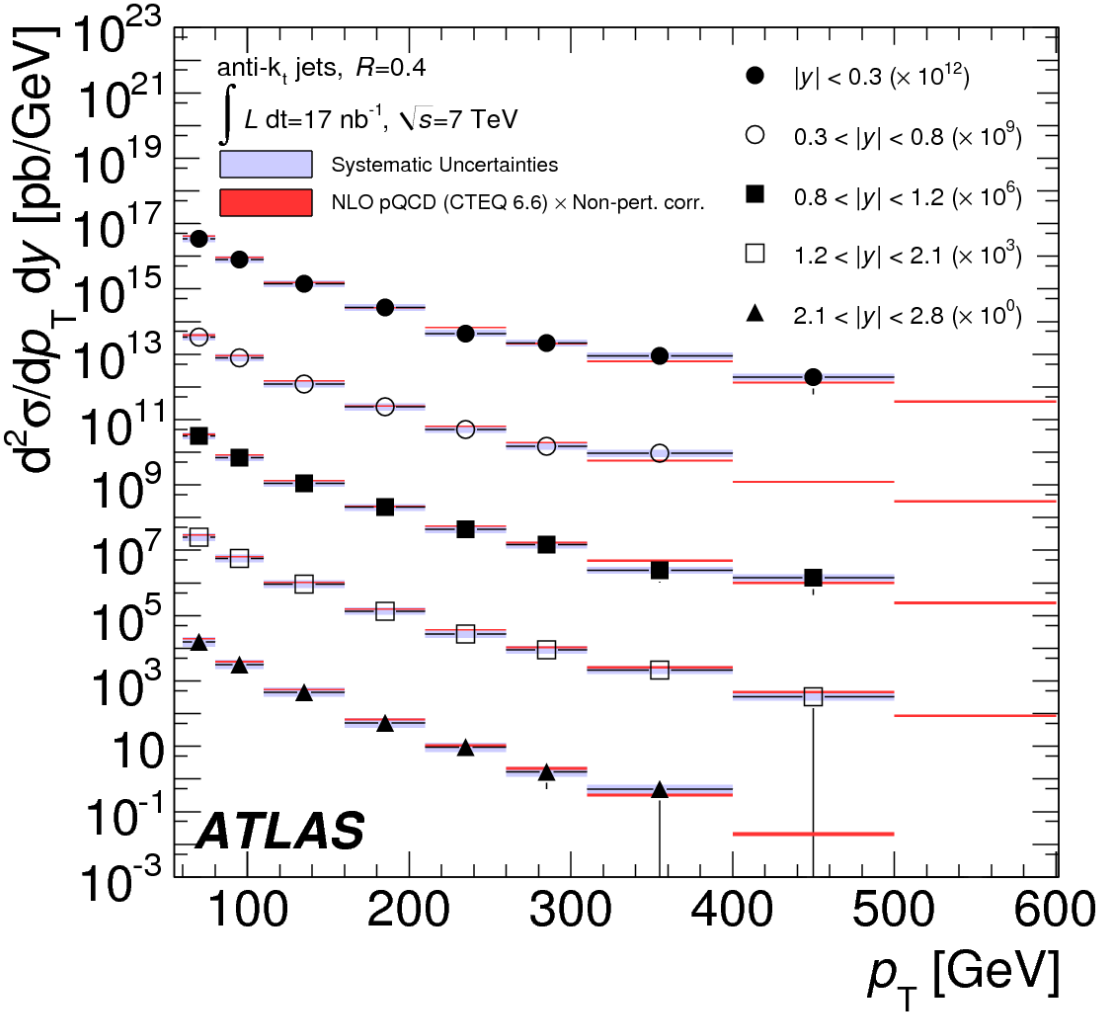
- Leading jet p_T>60 GeV,
- Subleading p_T>30 GeV



- Count jets with p_T>60 GeV
- One event with 8 jets



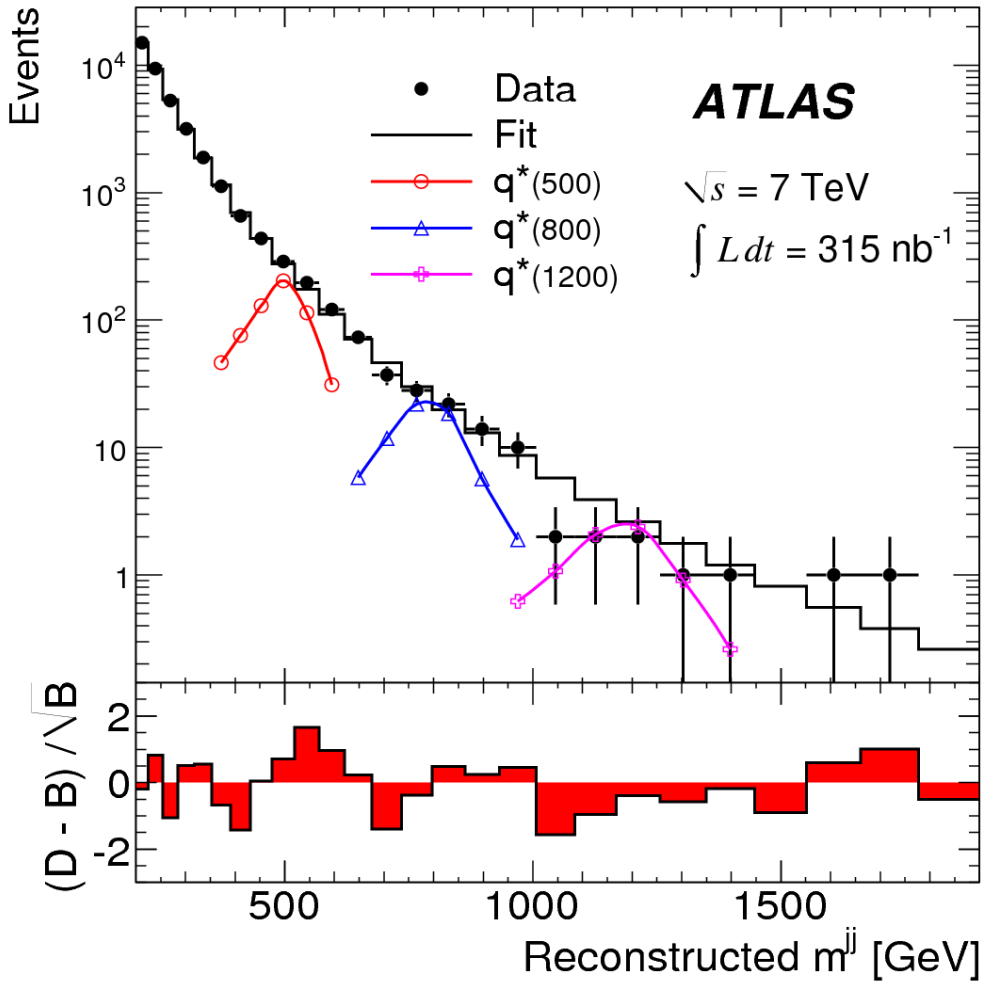
Inclusive Jet Cross Sections



Measurement of inclusive jet and dijet cross sections in proton-proton collisions at 7 TeV centre-of-mass energy with the ATLAS detector, Submitted to EPJC (30 Sep 2010)

Inclusive jet double-differential cross section as a function of jet p_T in different regions of |y| for jets identified using the anti-kt algorithm with R = 0.4. The data are compared to NLO pQCD calculations to which soft QCD corrections have been applied.

Search of Dijets for New Particles

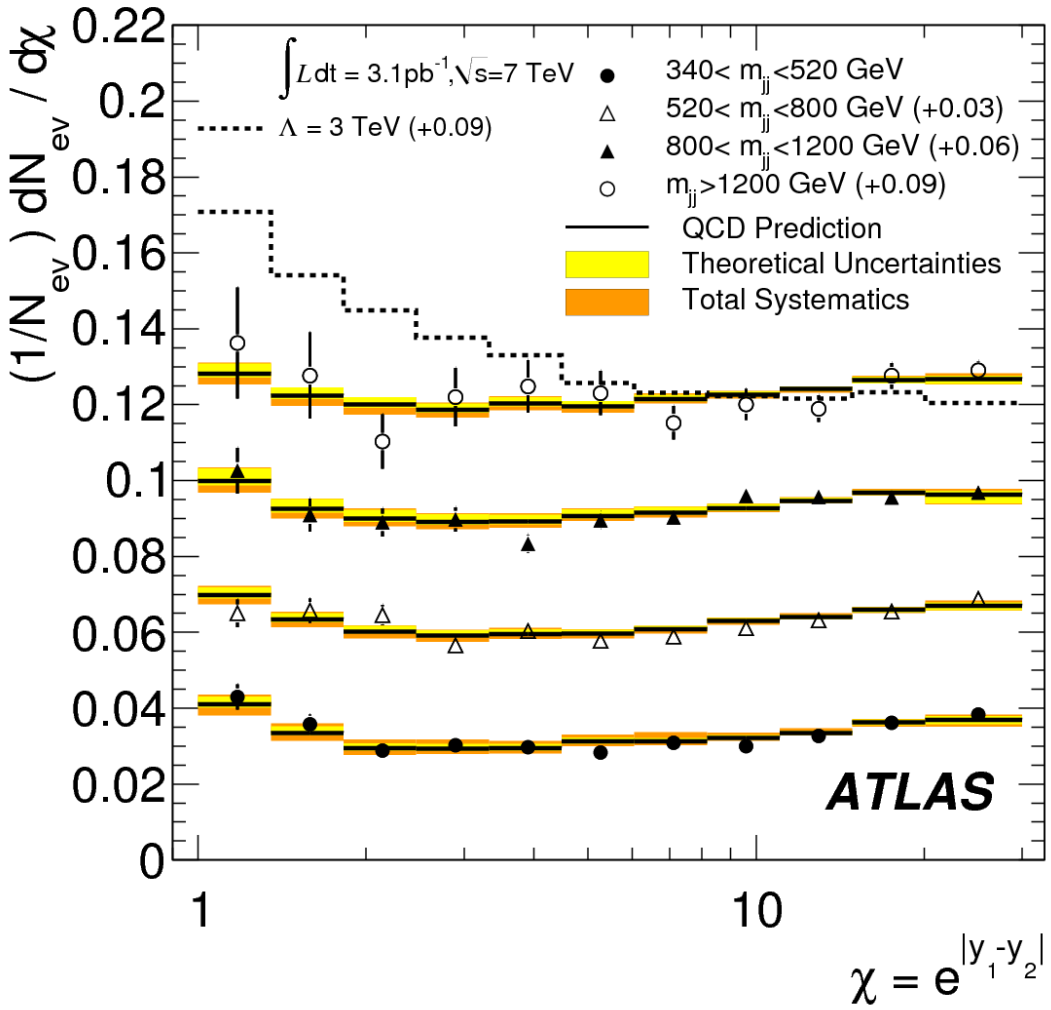


Search for New Particles in Two-Jet Final States in 7 TeV Proton-Proton Collisions with the ATLAS Detector at the LHC, Phys. Rev. Lett. 105, 161801 (14 Aug 2010)

The data dijet mass distribution (filled points) fitted using a binned background (B) distribution (histogram). The predicted q* signals for excited-quark masses of 500, 800, and 1200 GeV are overlaid, and the bin-by-bin significance of the data-background difference is shown.
These exclude at the 95% CL the q* mass interval $0.30 < m_{q^*} < 1.26$ TeV

Previous best published limit: CDF ($1\ fb^{-1}$): $260 < M(q^*) < 870$ GeV

Search for Quark Contact Interactions



Search for Quark Contact Interactions in Dijet Angular Distributions in in 7 TeV Proton-Proton Collisions with the ATLAS Detector at the LHC, accepted by PLB (submitted 26 Sep 2010)

Normalized χ distributions for $340 < m_{jj} < 520$ GeV, $520 < m_{jj} < 800$ GeV, $800 < m_{jj} < 1200$ GeV, and $m_{jj} > 1200$ GeV, with plotting offsets shown in parentheses. Shown are the QCD predictions with systematic uncertainties (bands), and data points with statistical uncertainties. The prediction for QCD with an added quark contact term with $\Lambda = 3.0$ TeV is shown for the highest mass bin $m_{jj} > 1200$ GeV.

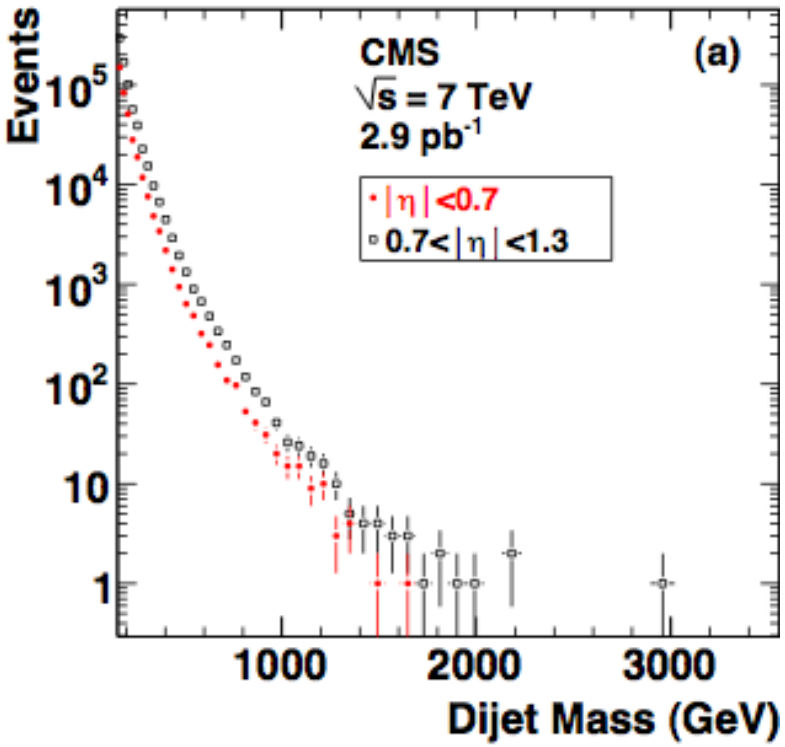
Analysis of the χ distributions excludes quark contact interactions with a compositeness scale Λ below 3.4 TeV, at 95% confidence level, significantly exceeding previous limits.

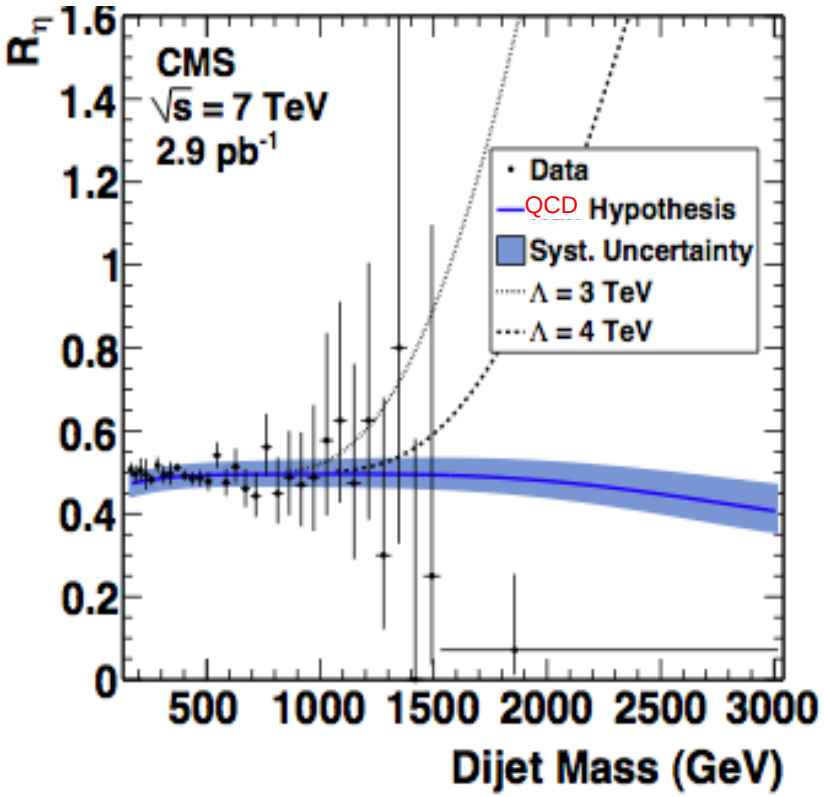
CMS Quark compositeness/QCD

Centrality ratio

$$R_\eta = \frac{\sum_{|\eta|<0.7} Dijets}{\sum_{0.7<|\eta|<1.3} Dijets}$$

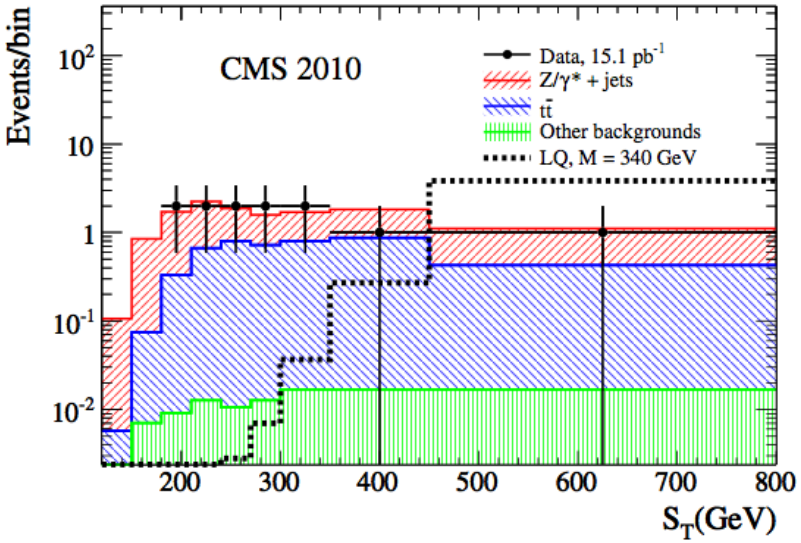
Contact interaction: excluded for Λ<4 TeV (higher than expected –2.9 TeV- due to fewer-than-expected events at high Dijet mass)



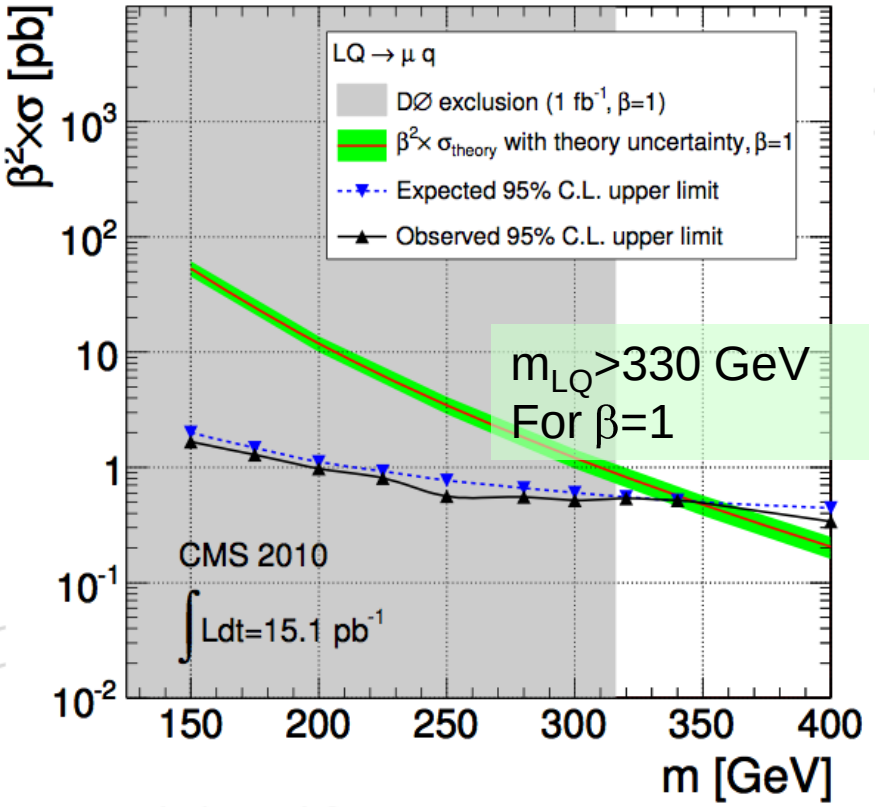


CMS Leptoquark search

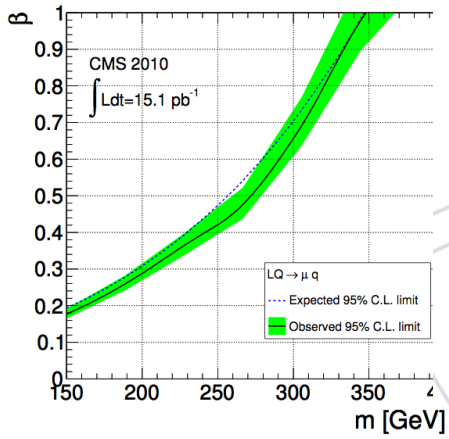
- Search for pair produced LQ decaying β % in μ+jet



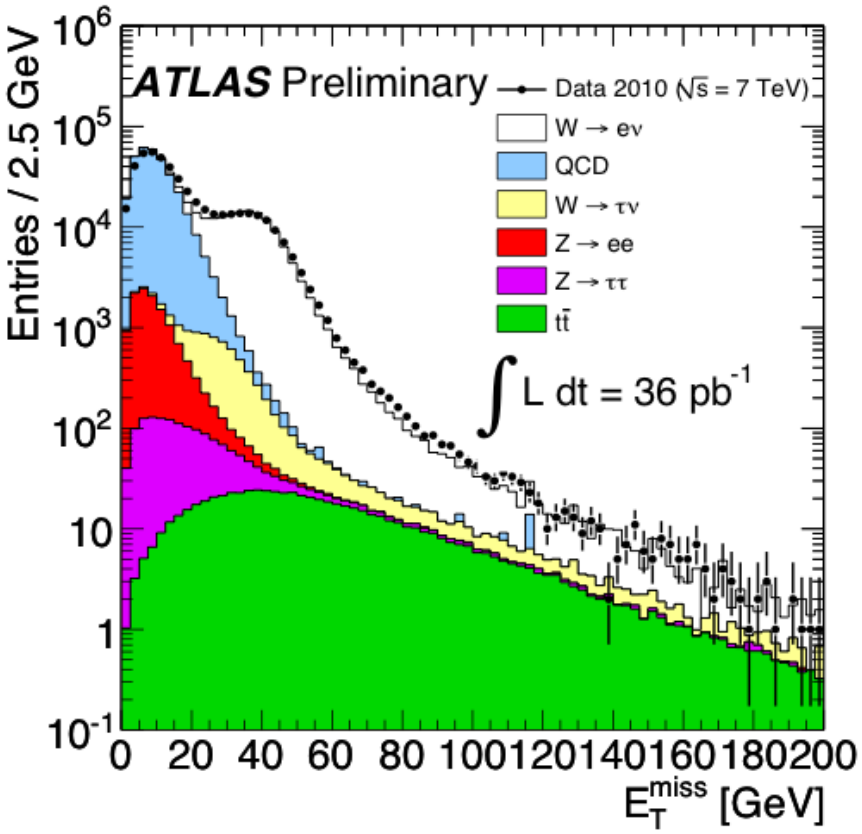
Final discri variable $S_T = \sum_{\mu_{1,2}} p_t^{\mu} + \sum_{Jet_{1,2}} p_t^{jet}$

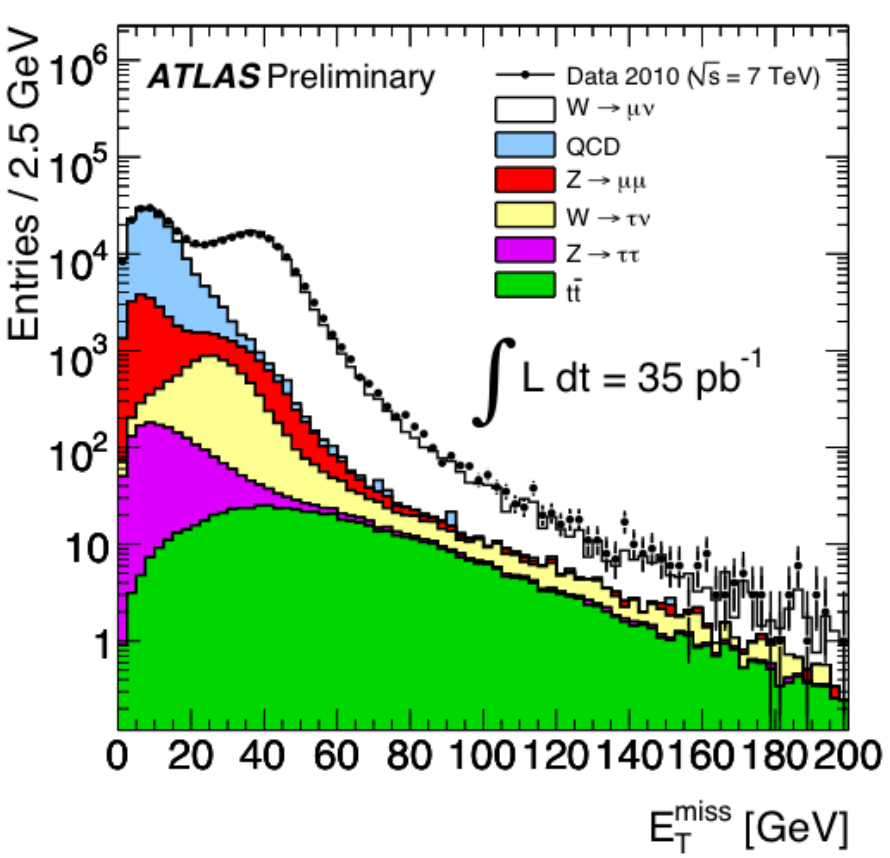


As a function of β (branching fraction)

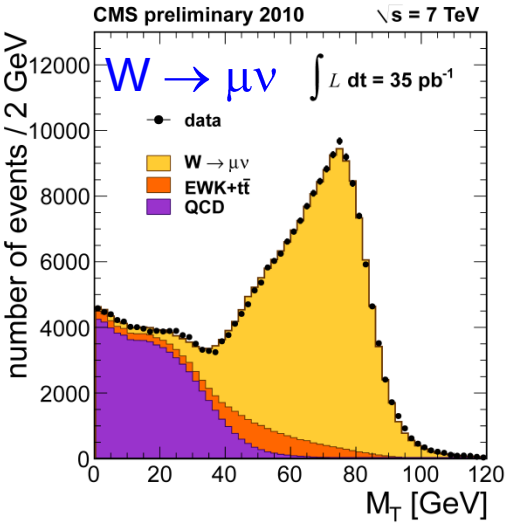


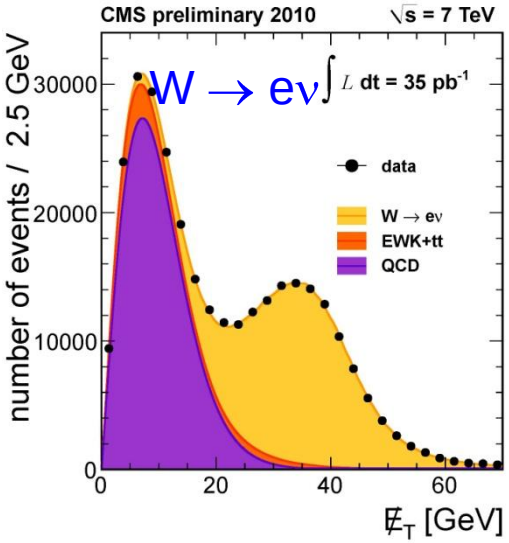
Missing transverse energy





CMS W and Z

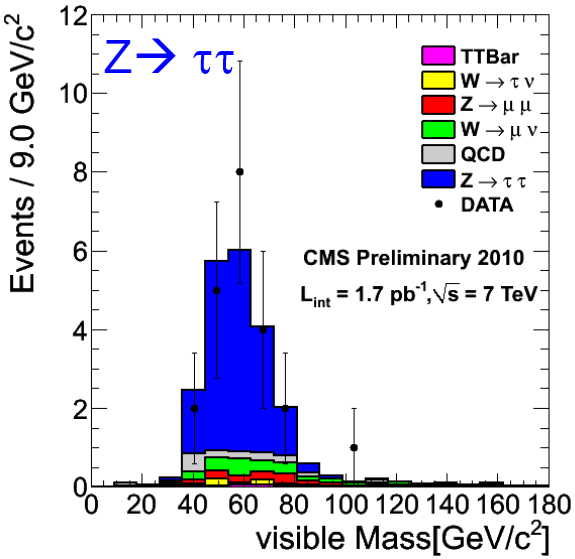


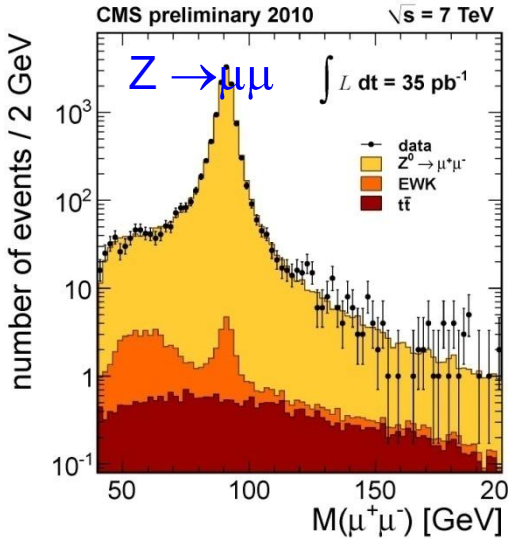


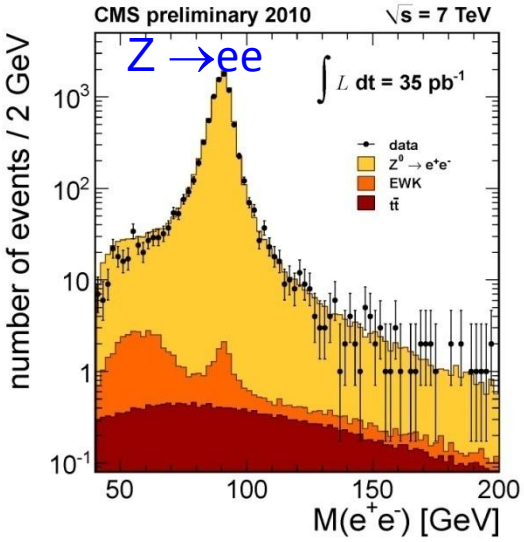
← W (35pb^{-1})

Z →ττ

↓



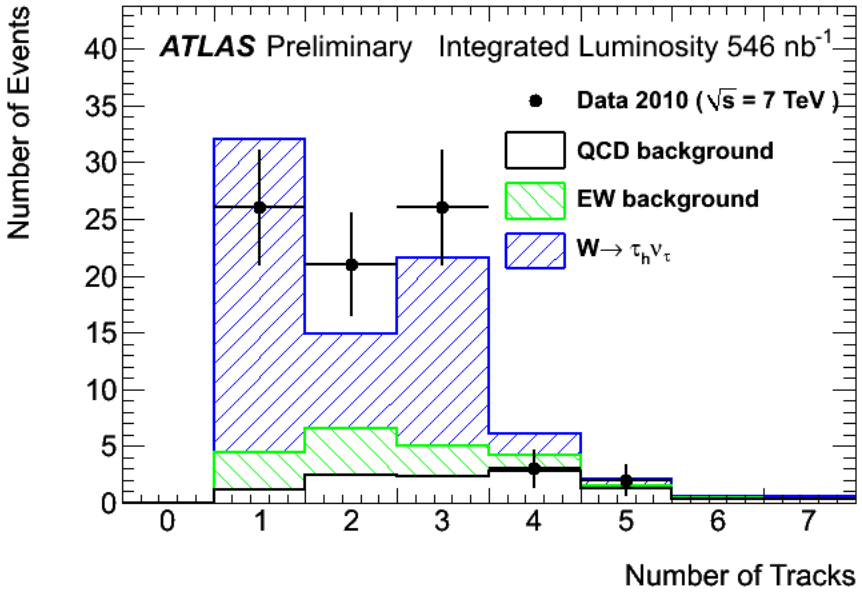


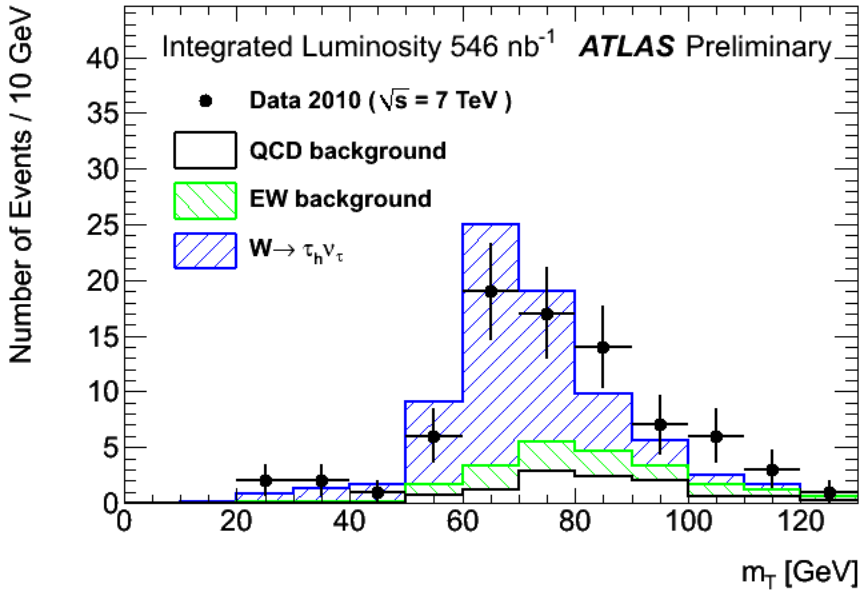


← Z (35 pb^{-1})

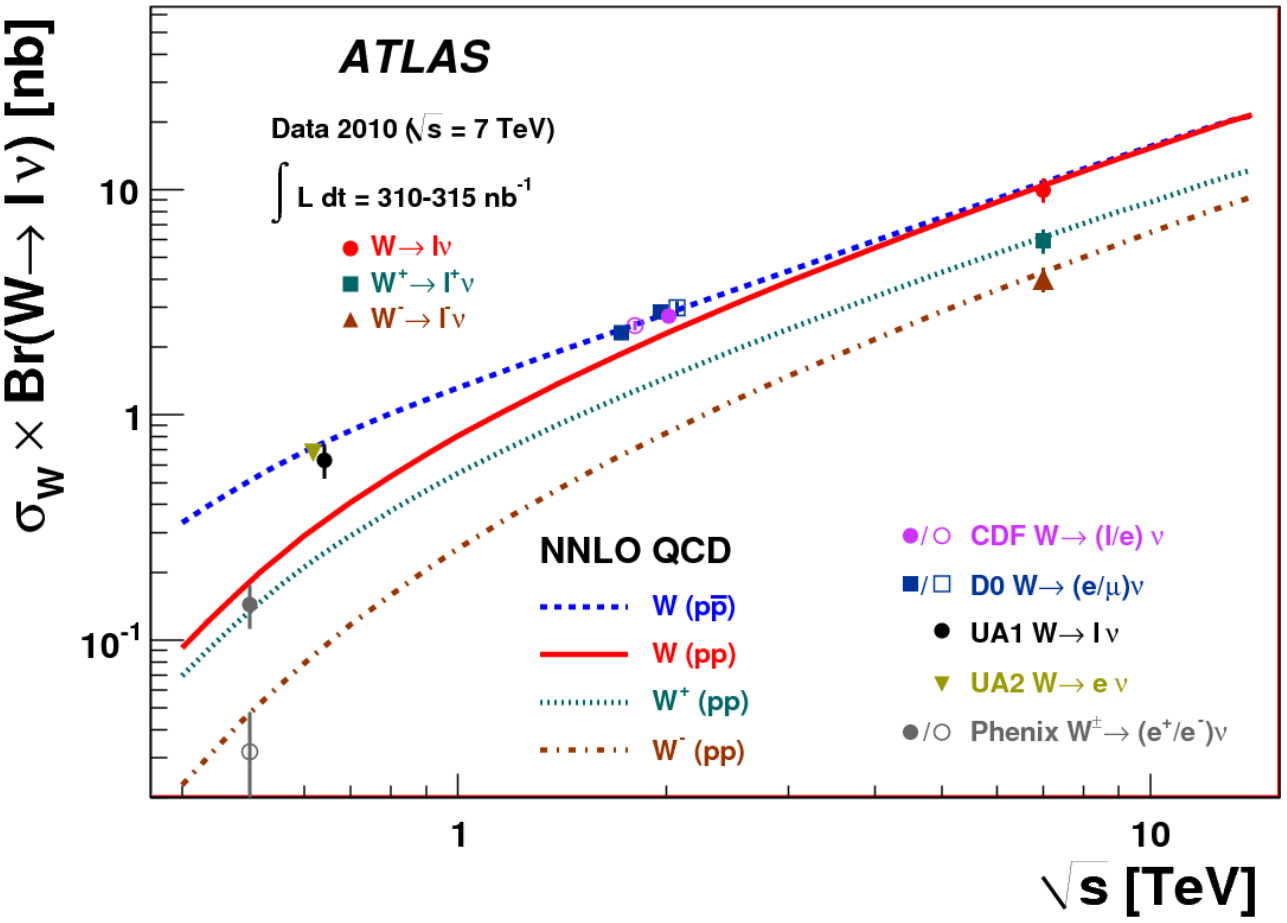
W→τν observation

- Observation of W→τν based on 550nb^{-1} also available.
- 78 events with hadronic τ decay candidates. Backgrounds:
- 11.1±2.3±3.2 from QCD
- 11.8±0.4±3.7 from other W/Z decays
- Event properties consistent with expectation





W, Z Cross Sections



Measurement of the W -> lν and Z/γ* -> ll production cross sections in proton-proton collisions at $\sqrt{s}$= 7 TeV with the ATLAS detector, submitted to JHEP (11 Oct. 2010)

The measured values of σ_W x BR(W to lυ) for W+, W- and for their sum compared to the theoretical predictions based on NNLO QCD calculations. Results are shown for the combined electron-muon results. The predictions are shown for both proton-proton (W+,W- and their sum) and proton-antiproton colliders (W) as a function of root(s). In addition, previous measurements at proton-antiproton and proton-proton colliders are shown. The data points at the various energies are staggered to improve readability. The CDF and D0 measurements are shown for both Tevatron collider energies, $\sqrt{s}$ = 1.8 TeV and $\sqrt{s}$ = 1.96 TeV. All data points are displayed with their total uncertainty. The theoretical uncertainties are not shown.

CMS $B_s \rightarrow J/\psi\,\phi$

Fit results:

$\mu_{gauss} = 5.3670 \pm 0.0012$ GeV/c^2

$\sigma_{gauss} = 16.4 \pm 1.2$ MeV/c^2

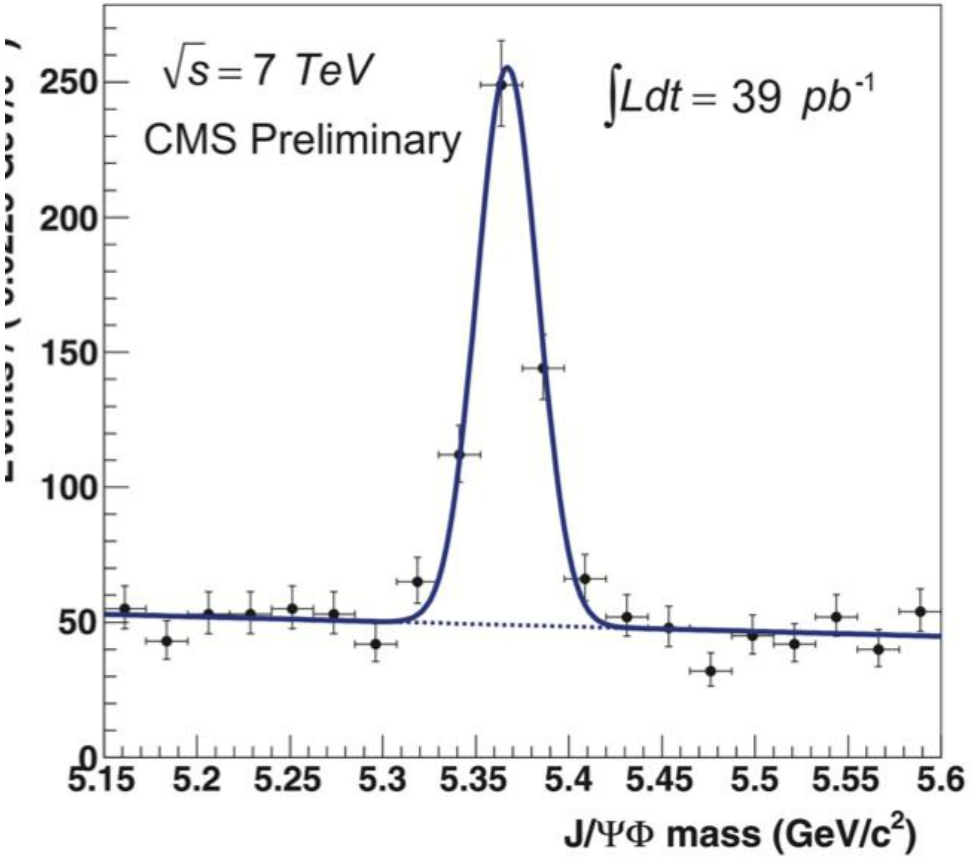
$N_{signal} = 377 \pm 26$

$N_{BG} = 978 \pm 36$

$\chi^2/ndof = 0.91$

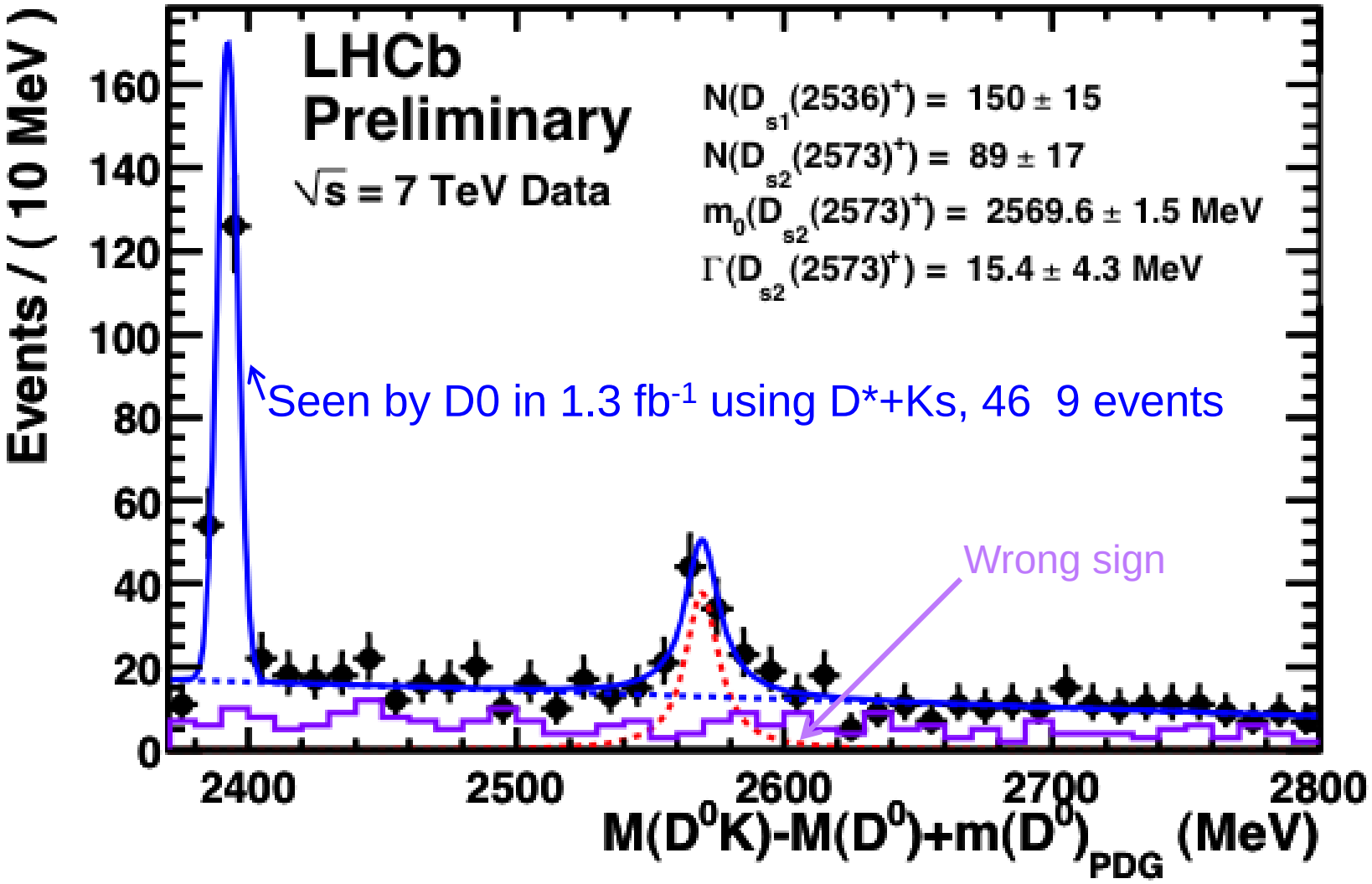
$S/\sqrt{(S+B)} \approx 10$

$S/B \approx 0.4$



LHCb: $B_s \rightarrow D_{s2} X \mu \nu$, $D_{s2} \rightarrow D^0 K^+$

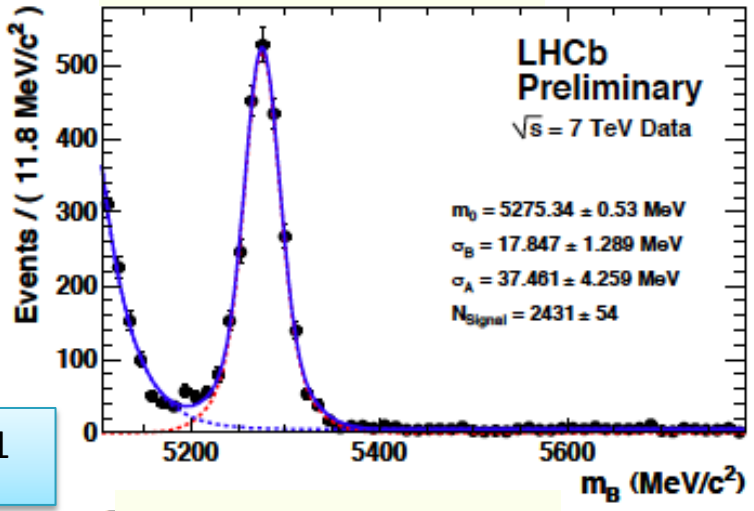
- New decay mode observed using 20 pb^{-1},



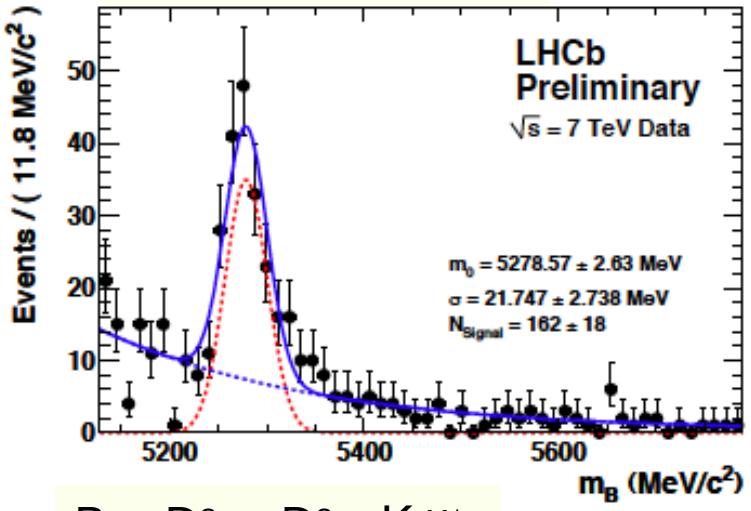
LHCb: $B^- \to D^0 h^-$

~12 pb^{-1}

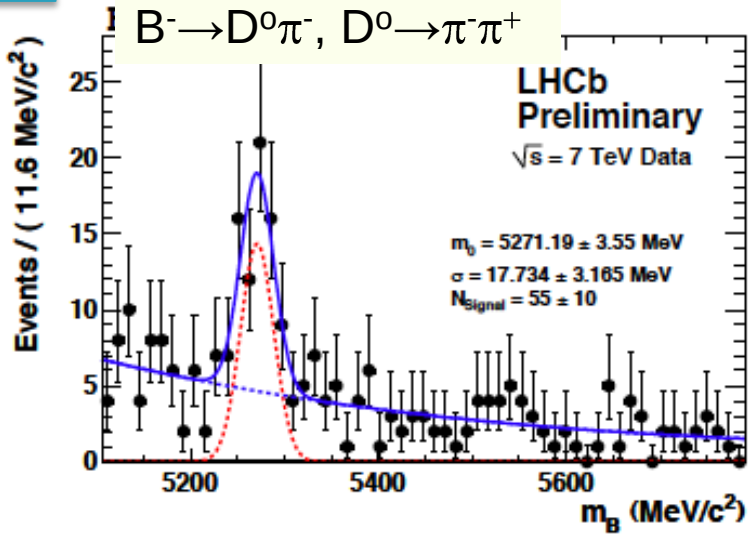
$B^- \to D^0\pi^-$, $D^0 \to K^-\pi^+$



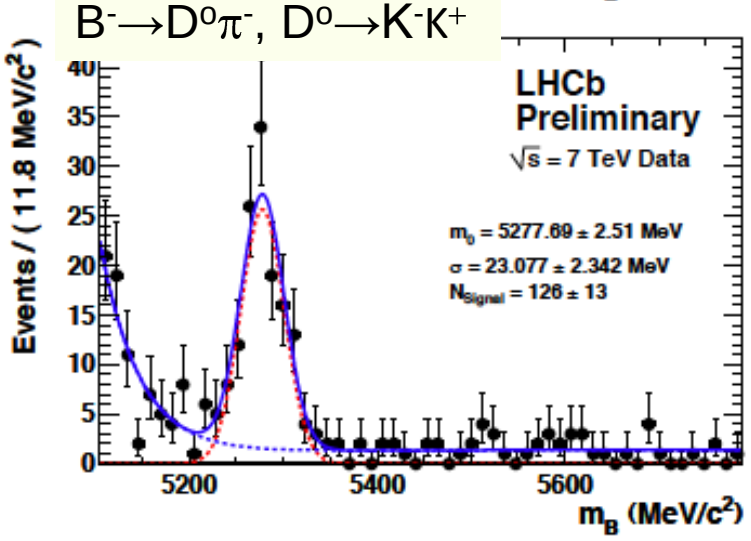
$B^- \to D^0 K^-$, $D^0 \to K^-\pi^+$



$B^- \to D^0\pi^-$, $D^0 \to \pi^-\pi^+$

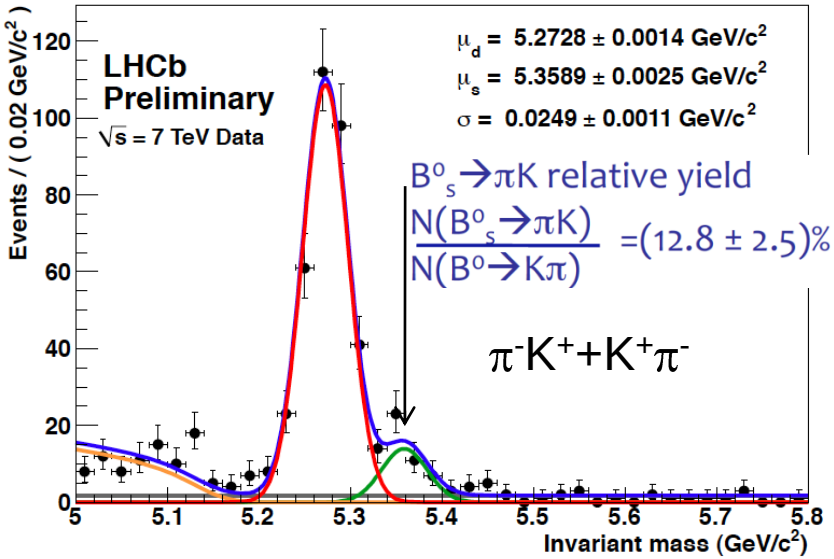


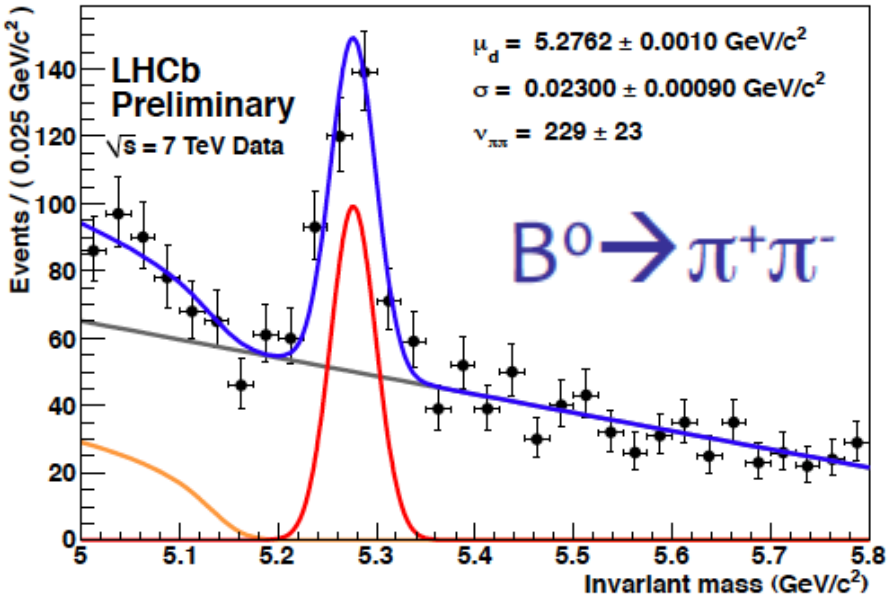
$B^- \to D^0\pi^-$, $D^0 \to K^-K^+$

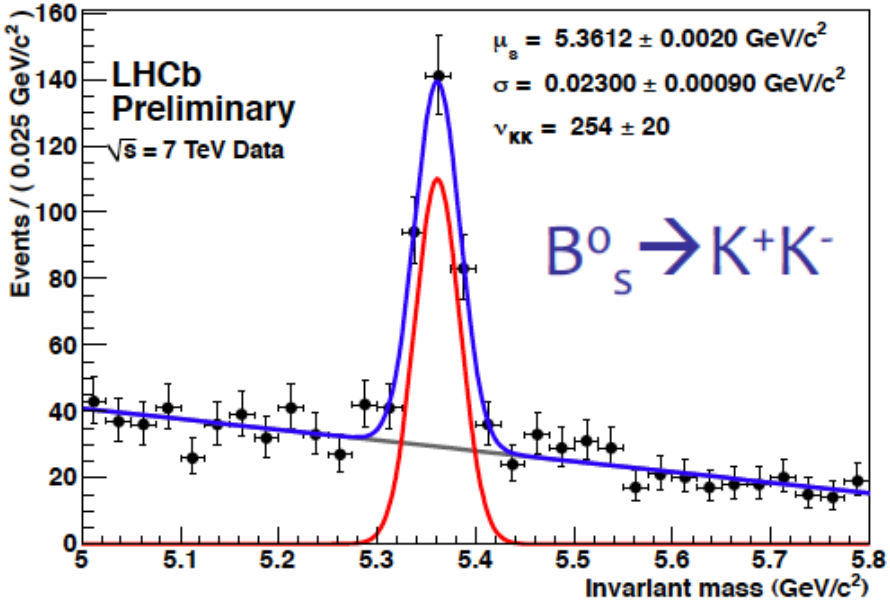


LHCb: $B^0 \to \pi K$, $\pi\pi$, KK

- Interesting for CP asymmetries
- 35 pb^{-1}



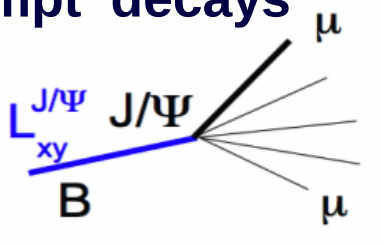




Fraction of J/ψ→μ+μ- from B Hadron decays

CMS

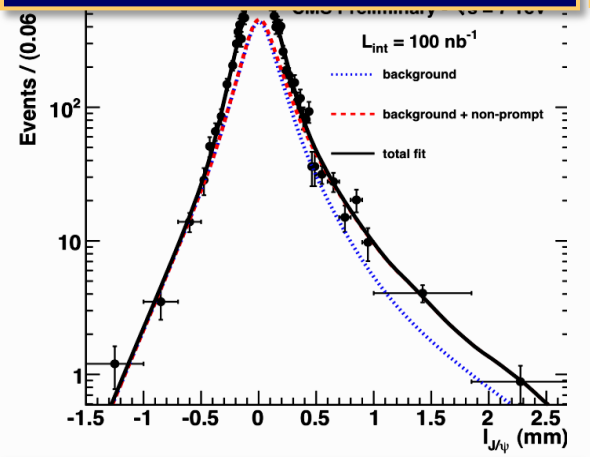
Traditional approach: the B transverse decay length used to separate prompt from non-prompt decays



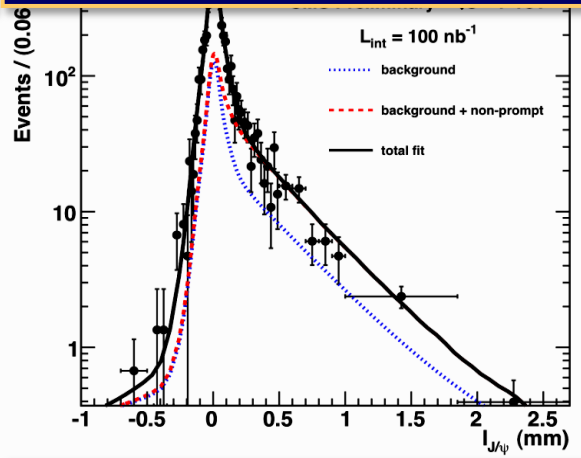
and to measure prompt (non-prompt) differential cross section.

Non prompt cross section:
BR(J/ψ→μ+μ−)·
σ(pp→bX→ J/ψ+X) =
56.1 5.5(stat) 7.2(syst) nb
(p_T > 4GeV/c and |y| <2.4)

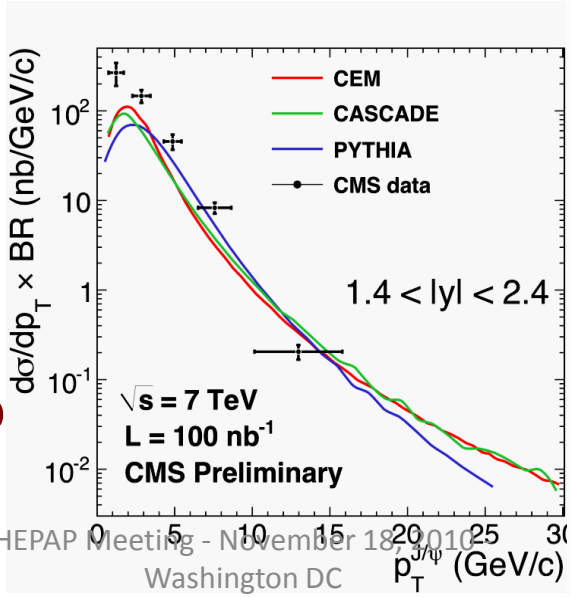
J/ψ Decay Length low p_T



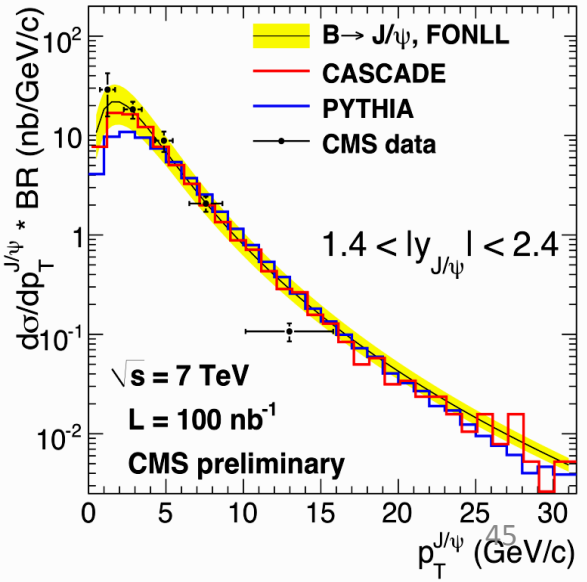
J/ψ Decay Length med. p_T



$d\sigma/dp_T$ Prompt J/ψ



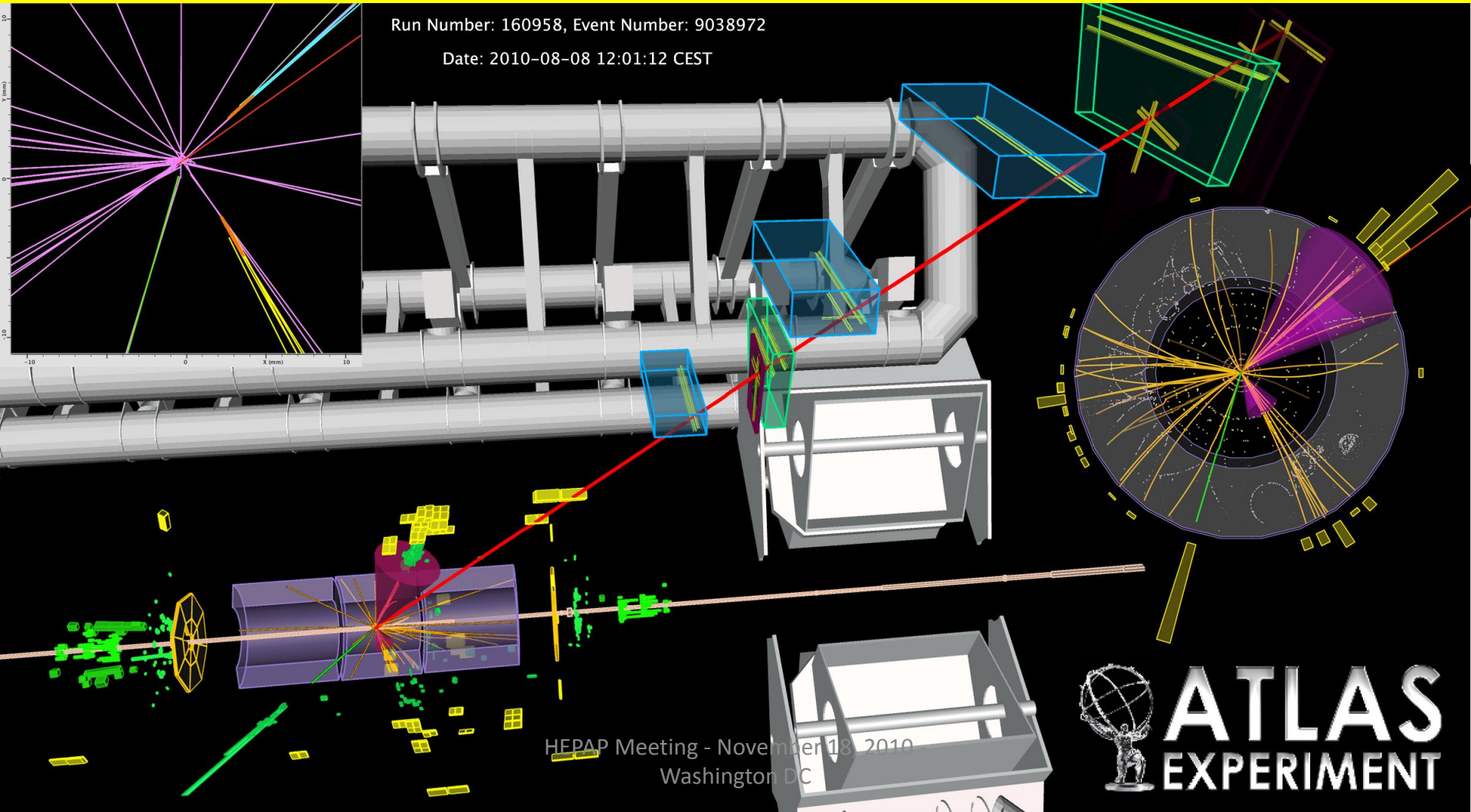
$d\sigma/dp_T$ Non-Prompt J/ψ



A gold-plated tt → beν, bμν candidate

$p_T(\mu)$= 51 GeV $p_T(e)$=66 GeV p_T (b-tagged jets) = 174, 45 GeV E_T^{miss} = 113 GeV,
Secondary vertices:
-- distance from primary vertex: 4mm, 3.9 mm
-- vertex mass : ~2 GeV, ~ 4 GeV

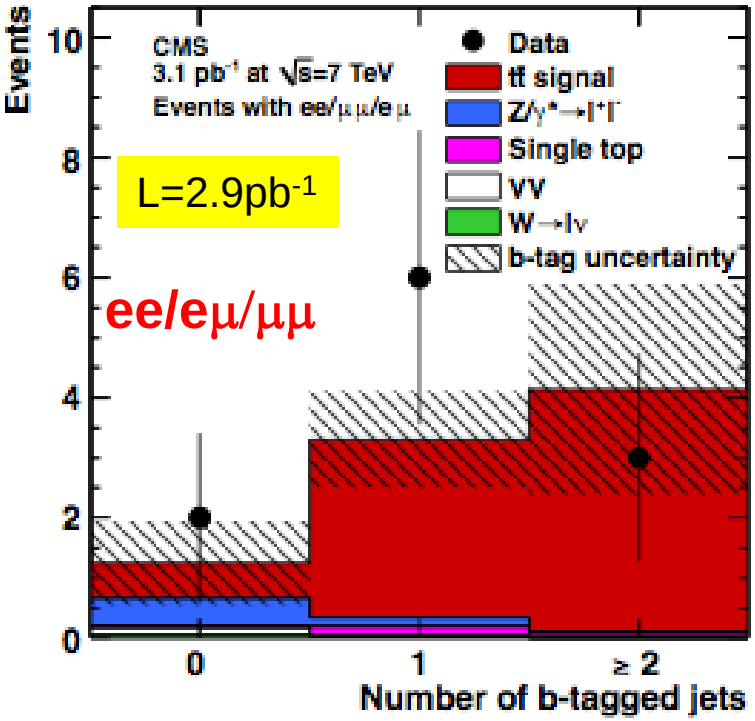
Purity > 96%

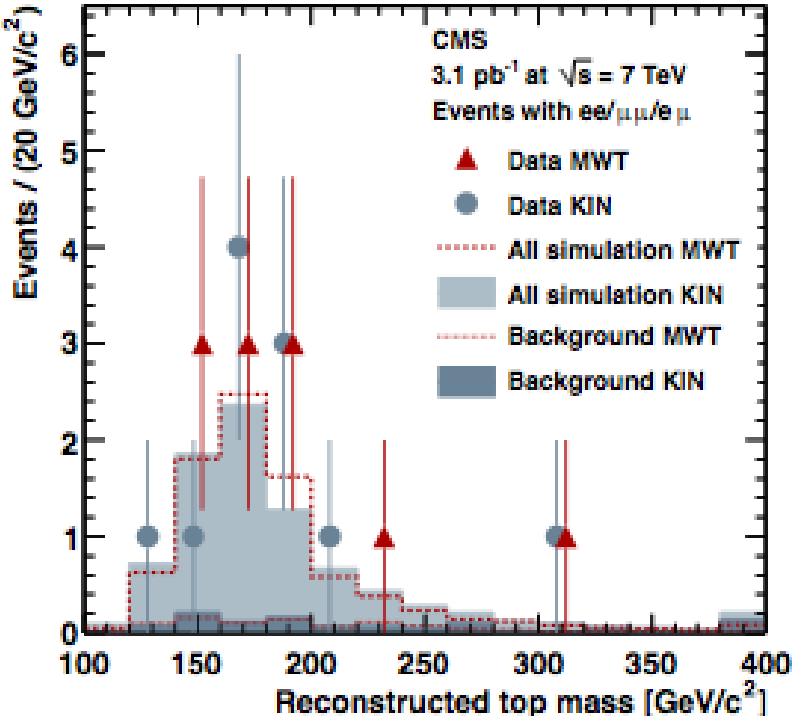


CMS: Top → two leptons plus jets

Full selection applied: Z-bosonVeto, |M(ll)-M(Z)|>15 GeV
MET >30 (20) GeV in ee,μμ, (eμ); N(jets)≥2

$\sigma(pp \to t\bar{t}) = 194 \quad 72(stat.) \quad 24(syst.) \quad 21(lumi.)$ pb

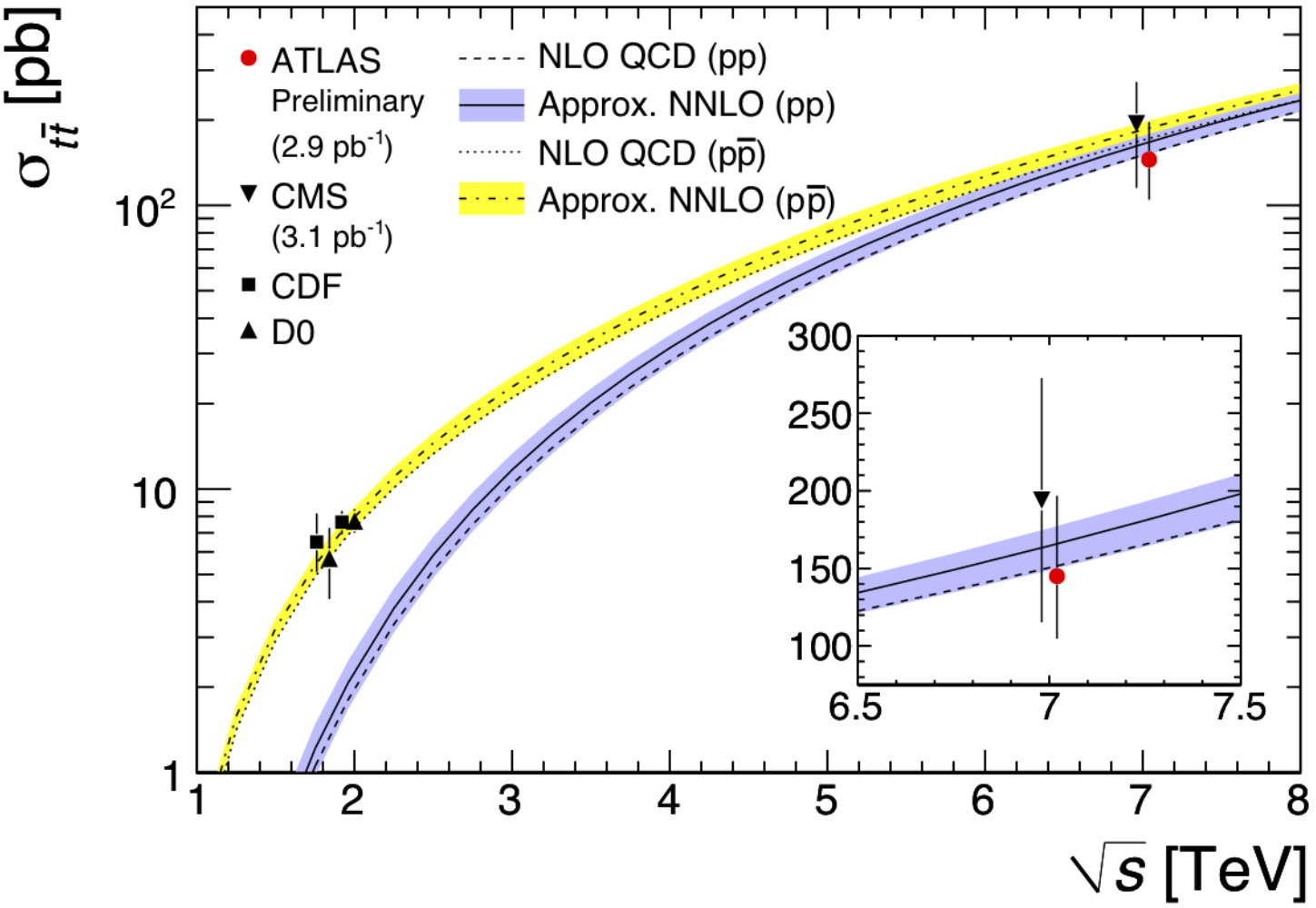




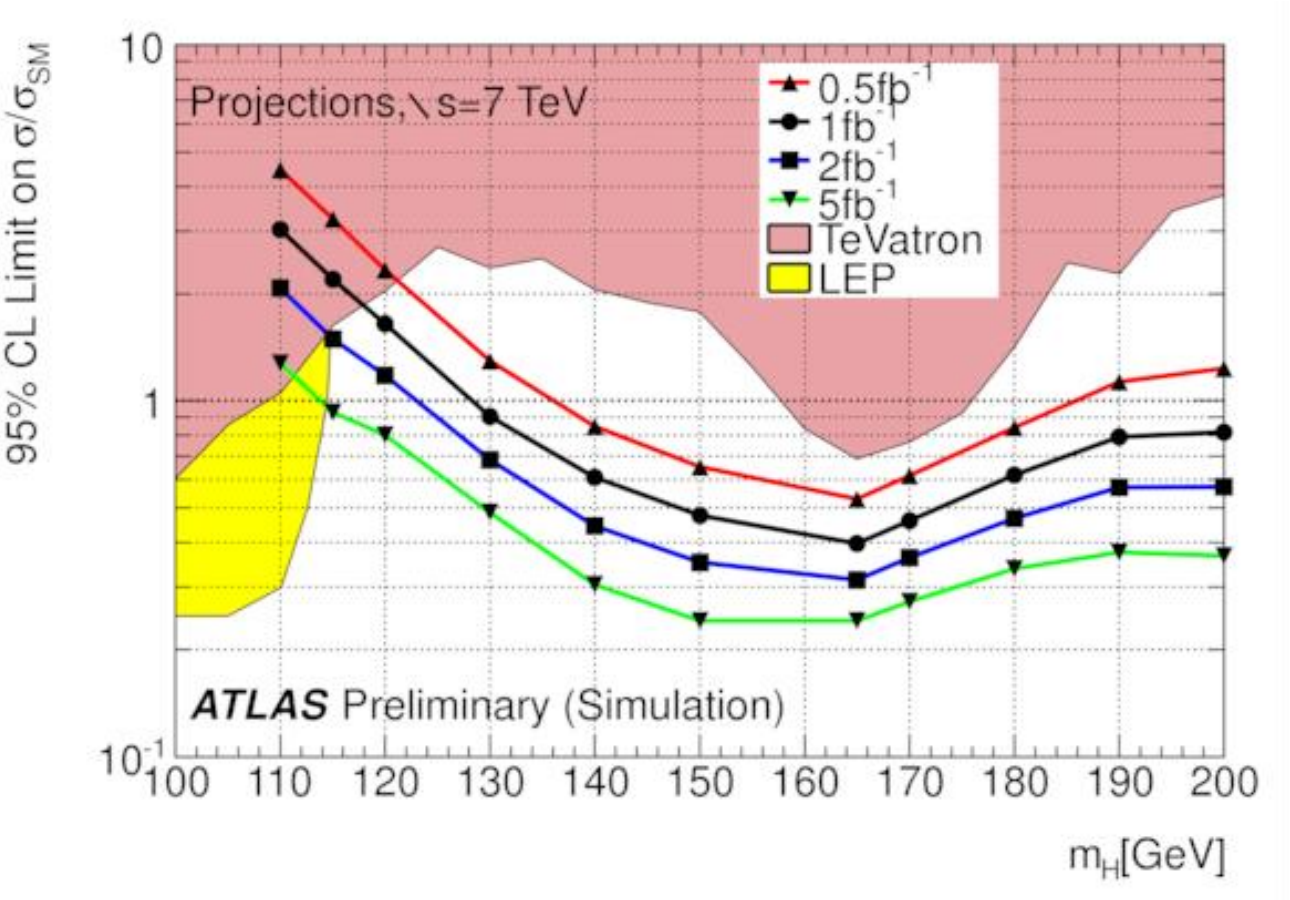
Accepted by PL-B - arXiv:1010.5994

Top production cross section

- Combining all channels $\sigma_{t\bar{t}} = 145 \pm 31^{+42}_{-27}$ pb
- Significance of ~4.8σ w.r.t. background only hypothesis.

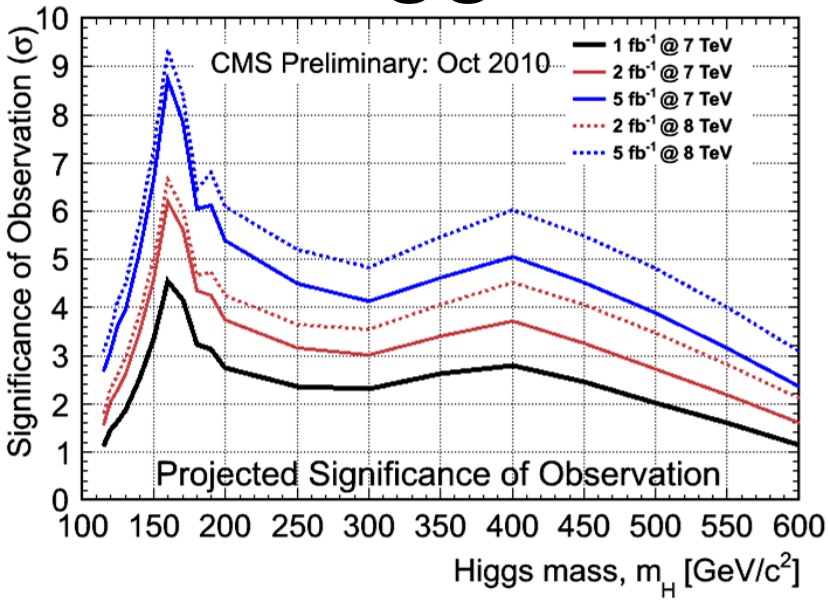


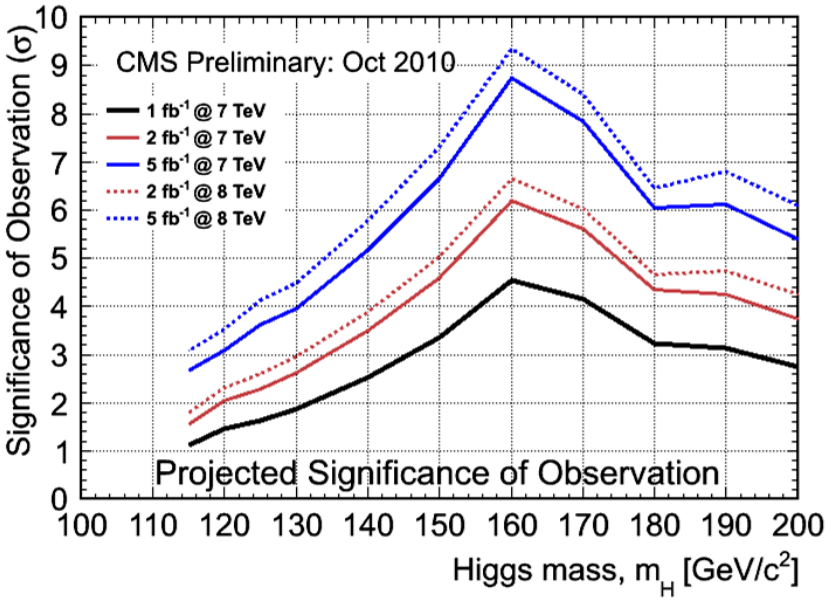
ATLAS Higgs Exclusion Reach



- $5fb^{-1}$ enough to close gap with LEP at 7 TeV
- Expected 3σ observation from 123 to 550 GeV

SM Higgs Observation Sensitivity





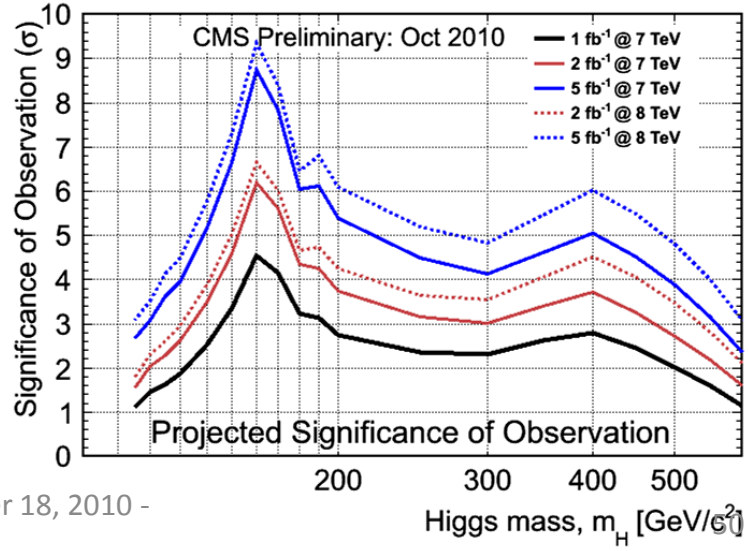
7 TeV, 1 fb^{-1}

"LHC" (2 x CMS) projected 3σ sensitivity: M_H = 135-475 GeV

8 TeV, 5 fb^{-1}

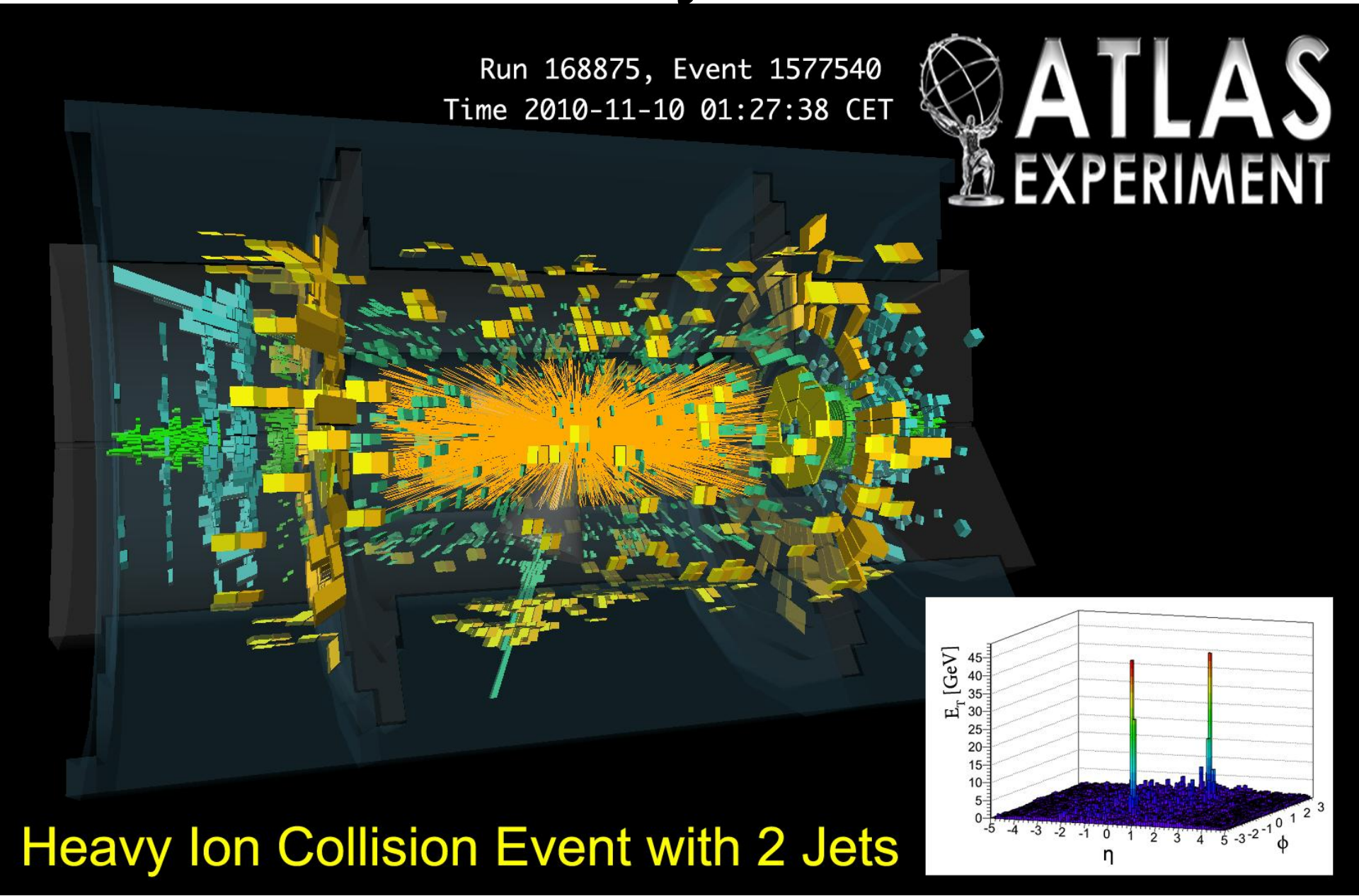
CMS projected 3σ sensitivity:

from LEP limit (114) up to 600 GeV



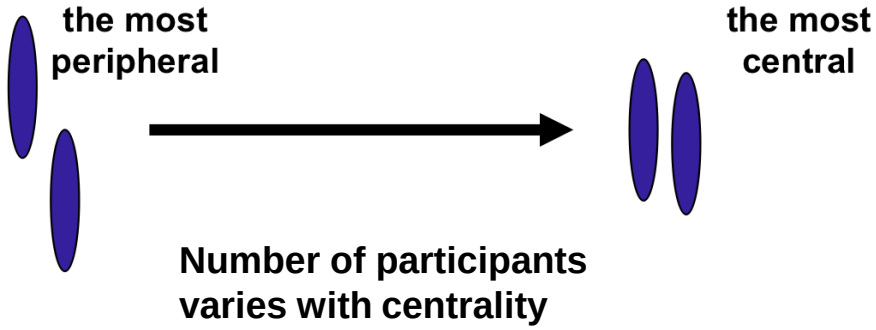
Pb-Pb event with jets

Uncorrected p_T of each jet ~160 GeV

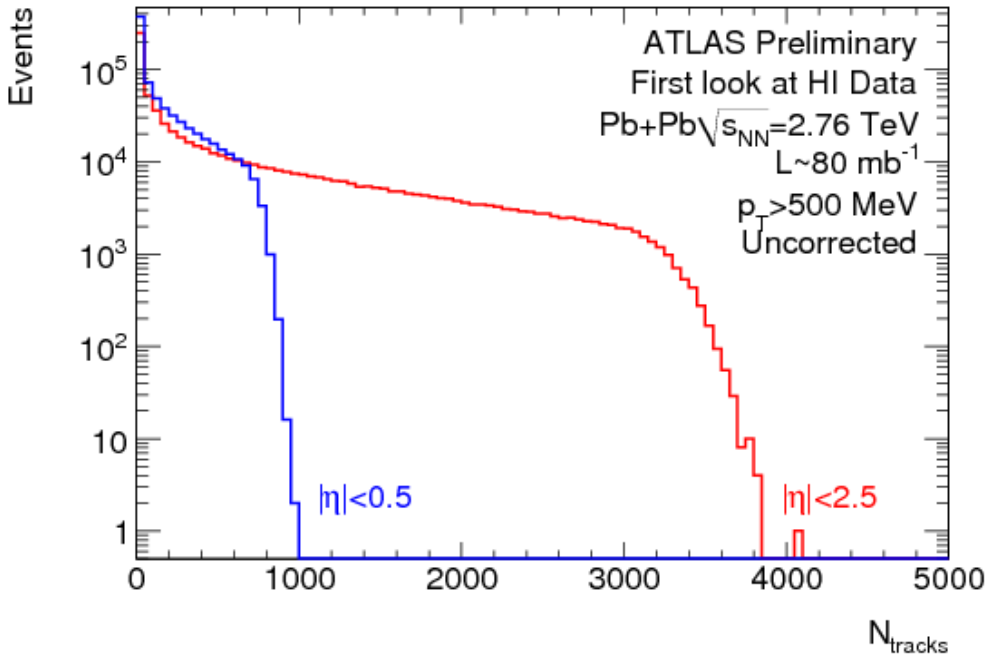


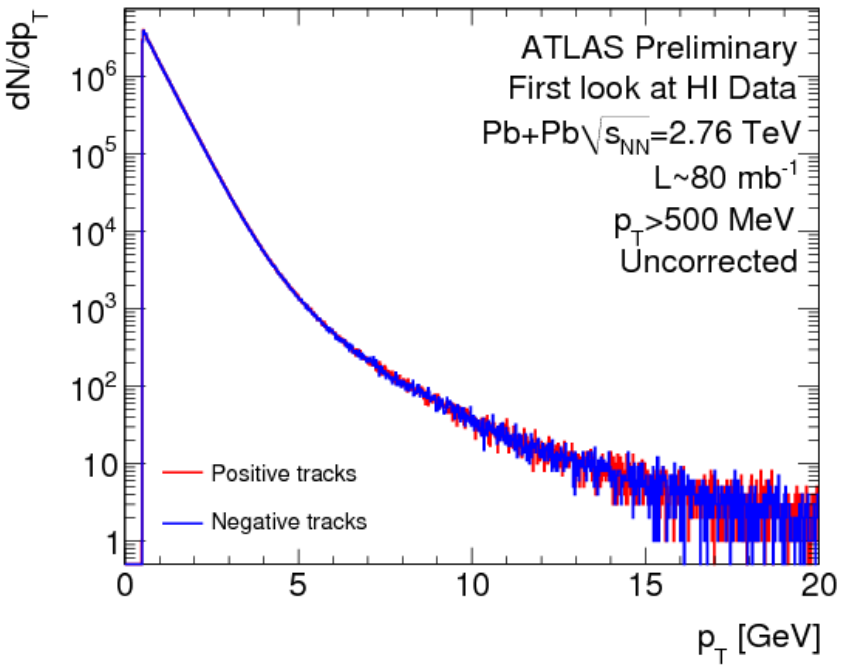
Heavy Ion Collision Event with 2 Jets

Tracks in Pb-Pb



- Distribution of N_{events} as a function of N_{tracks} shows anticipated features of varying centrality
- Distributions of positive & negative charged tracks are the same as a function of p_T

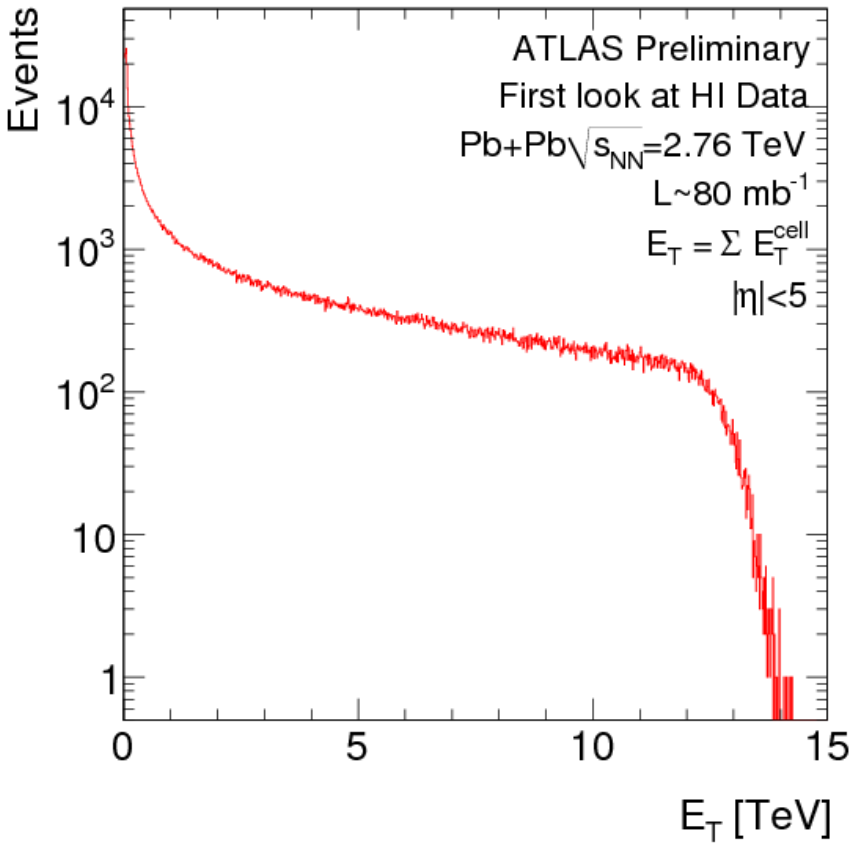


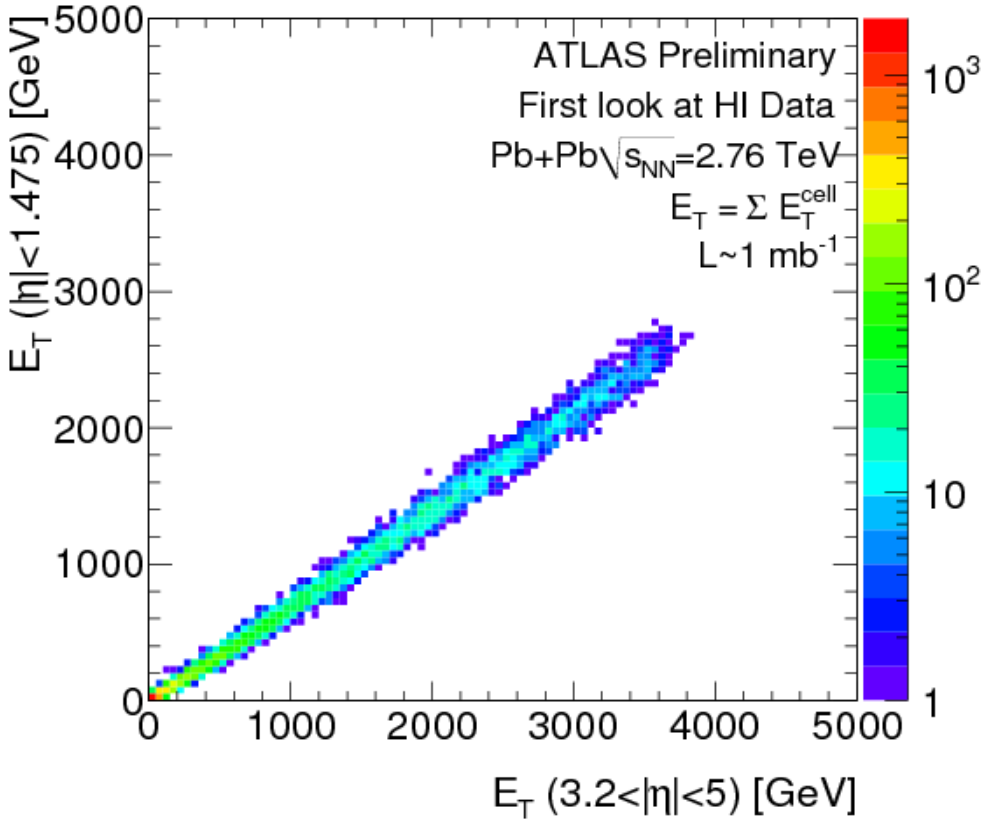


Transverse Energy in Pb-Pb

Distribution of N_{events} vs. E_T shows similar features to the distribution of N_{tracks}.

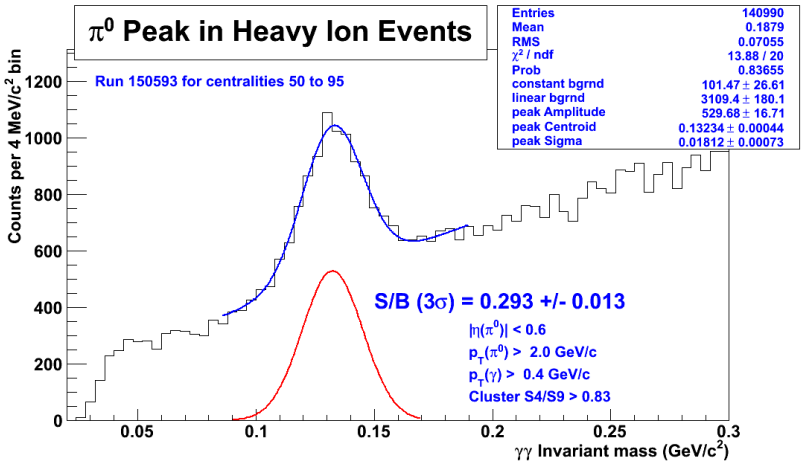
•Strong correlation observed between total E_T in the barrel and forward calorimeters.



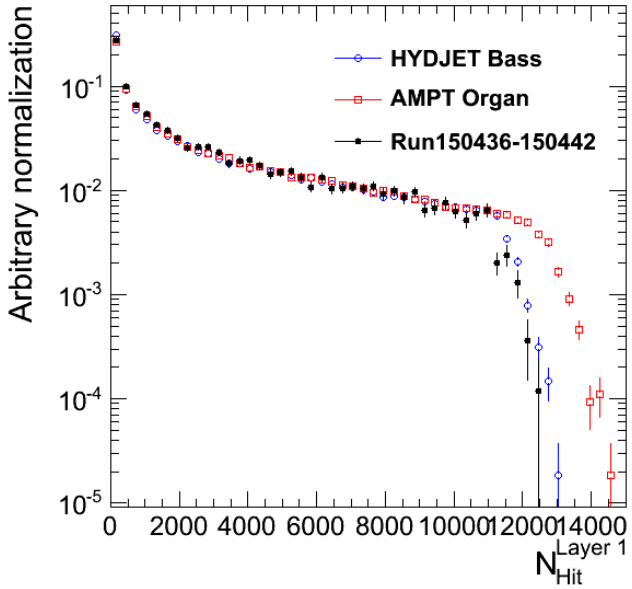


CMS Heavy Ion Preliminary Results

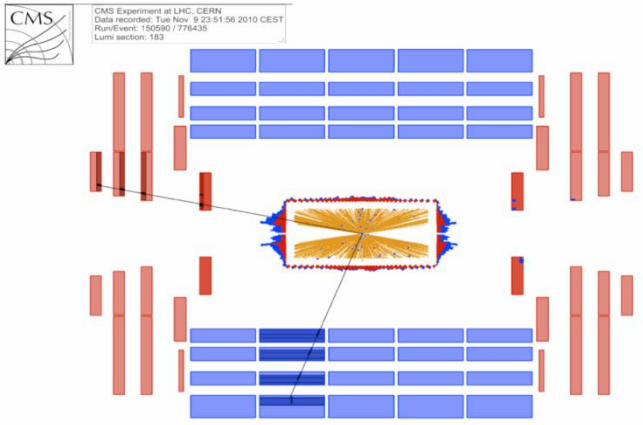
- Physics is fascinating
- Shows performance of CMS under extreme conditions



Despite a busier environment the π^0 looks the same as for pp (small mass bias due to non-corrected selection bias)

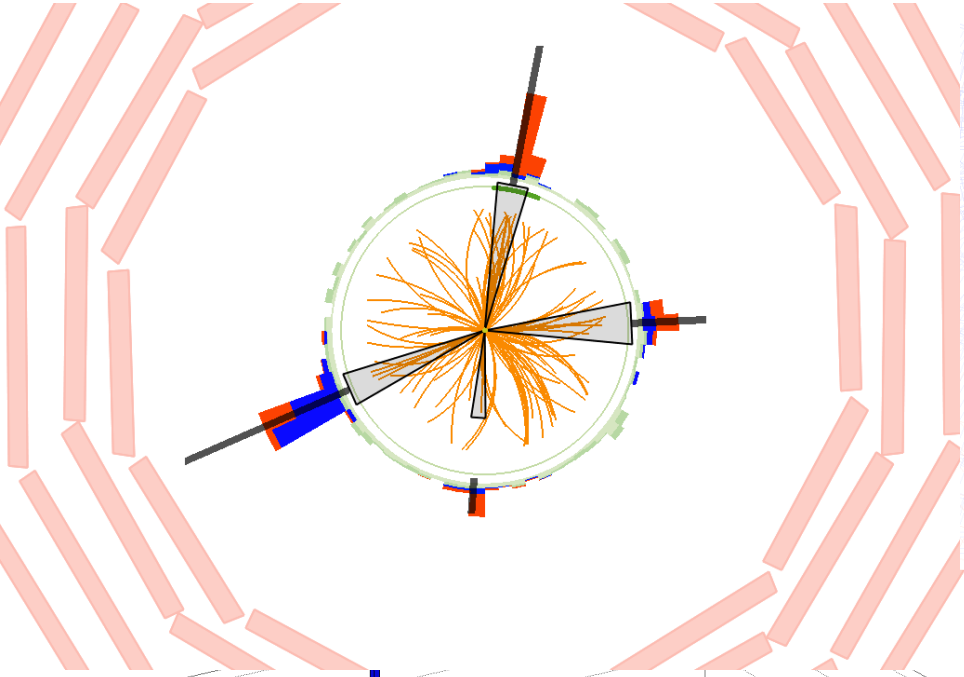


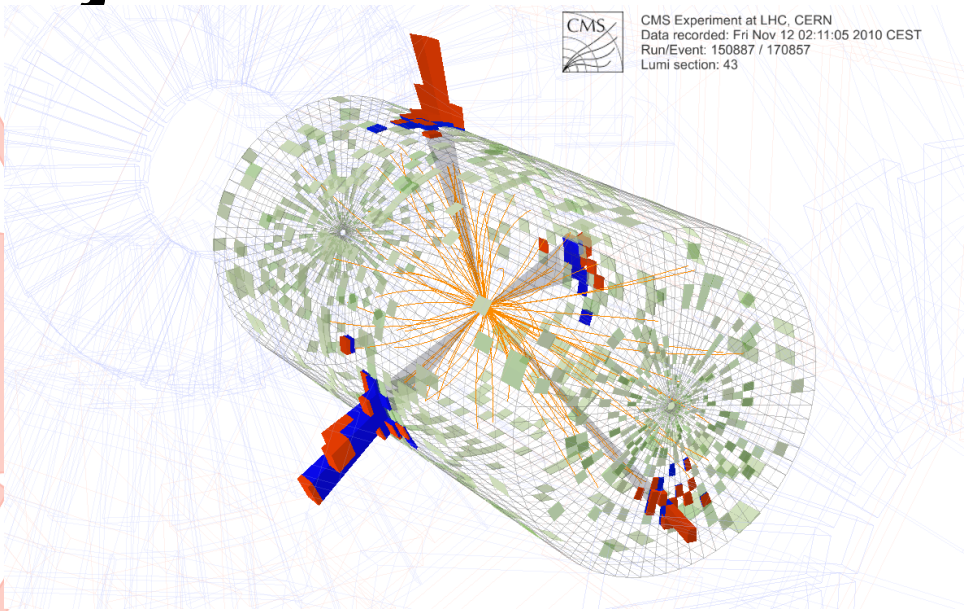
Pixel Hit multiplicity agrees well with MC tuned with RHIC AuAu and LHC pp collisions

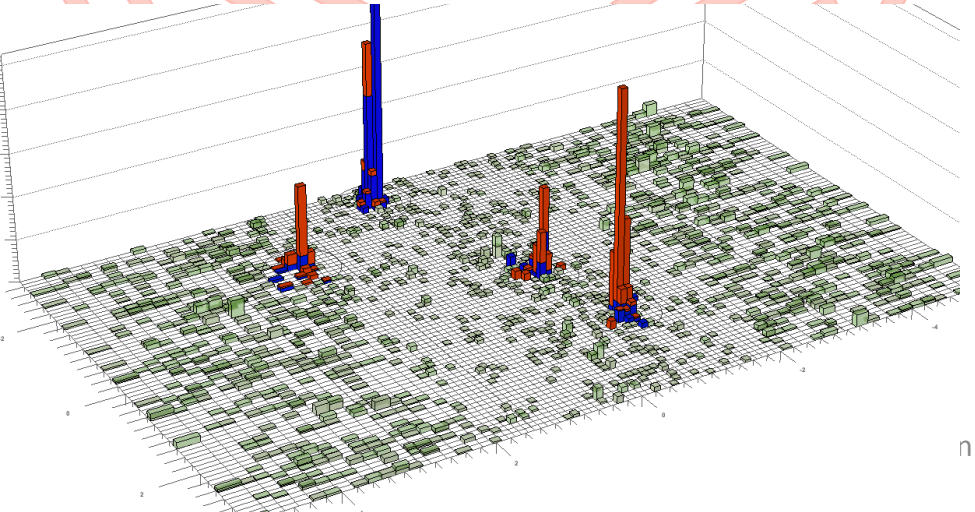


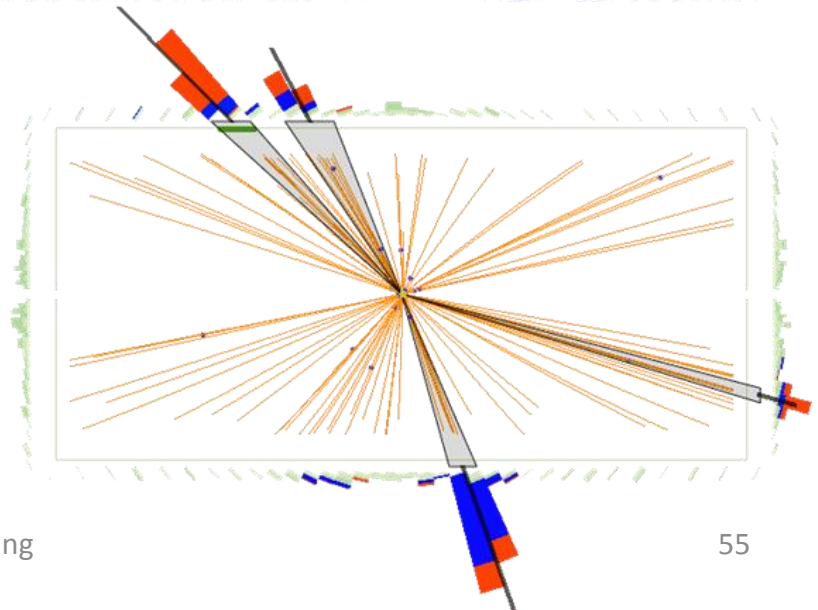
$M_{\mu+\mu-}$= 93 GeV : possibly the first Z ever seen in HI

CMS Heavy Ions: 4 jet









Conclusions

- All four experiments have had an exciting and productive year.
- We expect 2011 will have at least 1 fb^{-1} and therefore could yield some real discoveries.
- U.S. participation shows significant leadership in the physics results and appreciates the support from DOE and NSF!

Backup Slides

ATLAS Physics papers

Charged-particle multiplicities in pp interactions at sqrt(s) = 900 GeV measured with the ATLAS detector at the LHC	Phys Lett B 688, 1, 21
Search for New Particles in Two-Jet Final States in 7 TeV Proton-Proton Collisions with the ATLAS Detector at the LHC	Phys. Rev. Lett. 105, 161801
Search for Quark Contact Interactions in Dijet Angular Distributions in in 7 TeV Proton-Proton Collisions with the ATLAS Detector at the LHC	Accepted by PLB
Measurement of inclusive jet and dijet cross sections in proton-proton collisions at 7 TeV centre-of-mass energy with the ATLAS detector	Accepted by EPJC
Measurement of the $W \rightarrow l\nu$ and $Z/\gamma^* \rightarrow ll$ production cross sections in proton-proton collisions at sqrt(s) = 7 TeV with the ATLAS detector	Submitted to JHEP (11 Oct 2010)

- There will be many more!

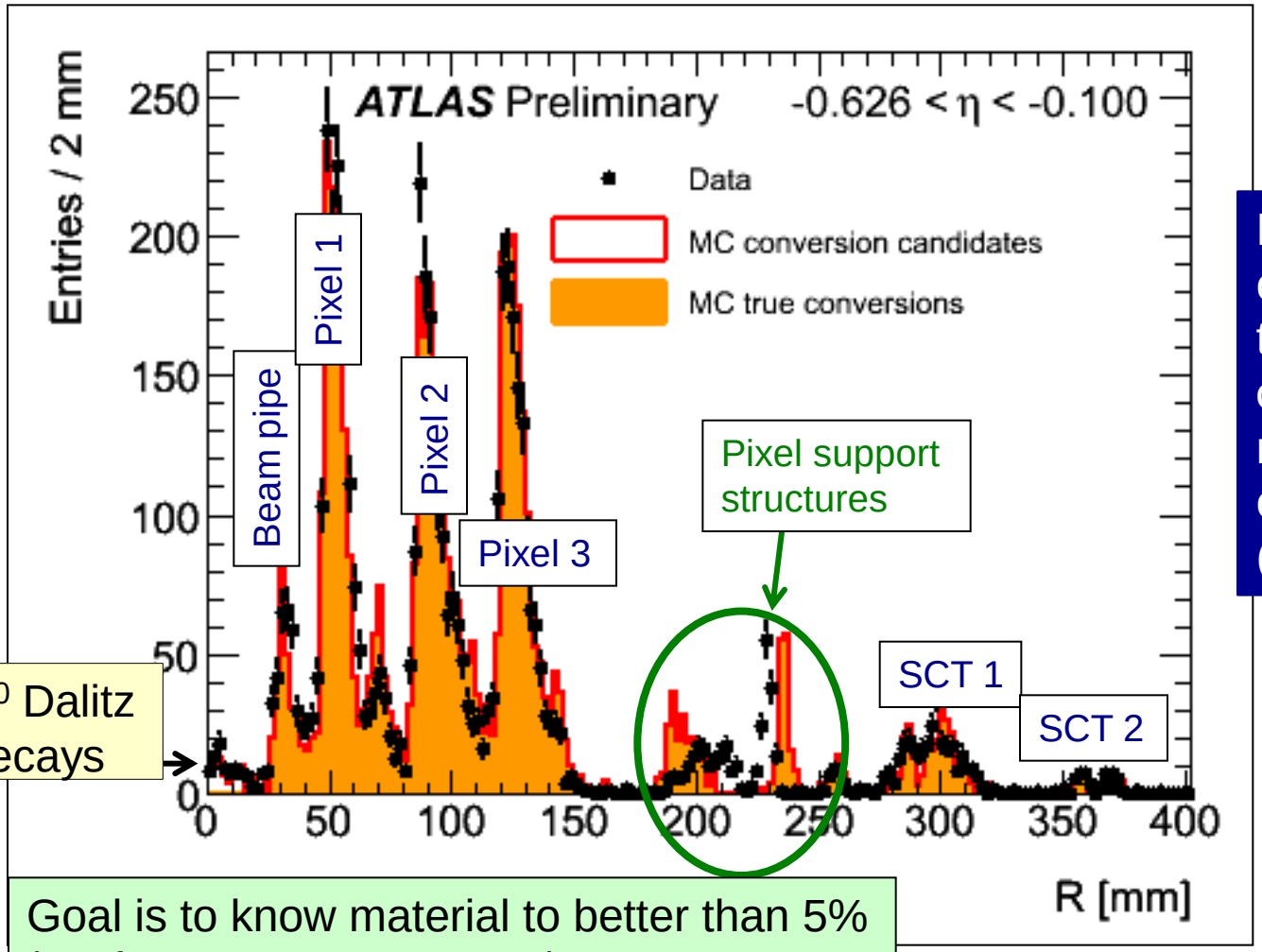
ATLAS Data quality

Inner Tracking Detectors			Calorimeters				Muon Detectors			
Pixel	SCT	TRT	LAr EM	LAr HAD	LAr FWD	Tile	MDT	RPC	CSC	TGC
99.0	99.9	100	90.5	96.6	97.8	94.3	99.9	99.8	96.2	99.8

Luminosity weighted relative detector uptime and good quality data delivery during 2010 stable beams at $\sqrt{s}$=7 TeV between March 30th and October 31st (in %). The inefficiencies in the calorimeters will largely be recovered in a future data reprocessing.

- Fraction of good quality data for the 45 pb^{-1} of pp data recorded
  - Problems in different subdetectors not correlated in time. With first-pass processing, ~40pb^{-1} for μ, 36 pb^{-1} for e or E_T^{miss} analyses
- LAr: HV trips and noise bursts
  - Will be partially recovered with reprocessing
- Tile: Incorrect bad channel masking for one fill
  - Will be fully recovered by reprocessing
- CSC: 6/16 problematic chambers on one side for three days
  - Chambers were recovered after an access.

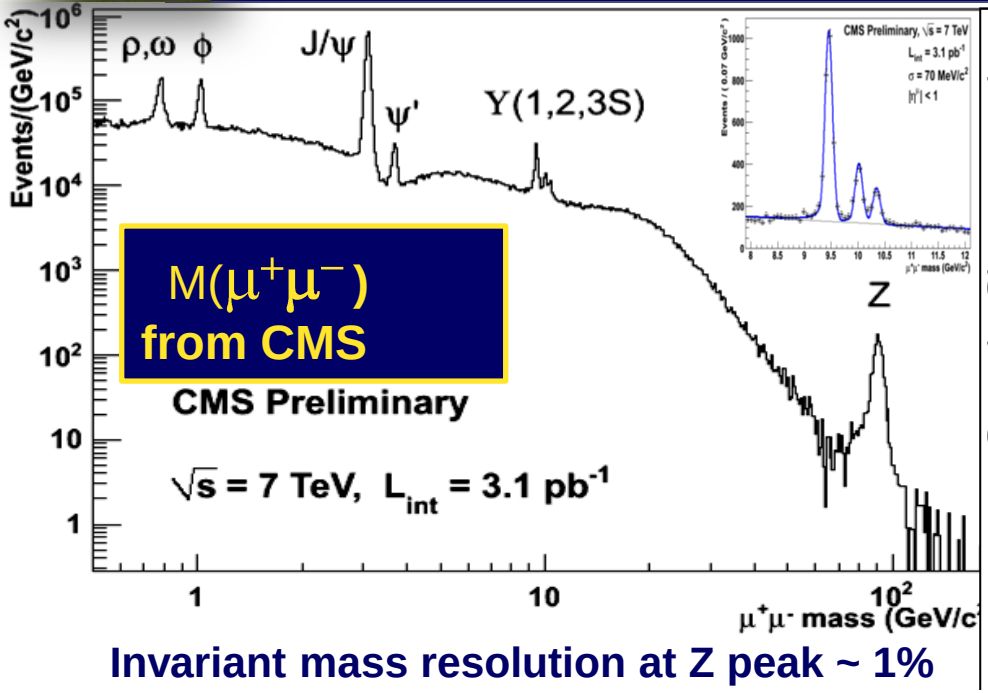
Mapping the Inner Detector material with $\gamma \rightarrow e^+e^-$ conversions and hadron interaction



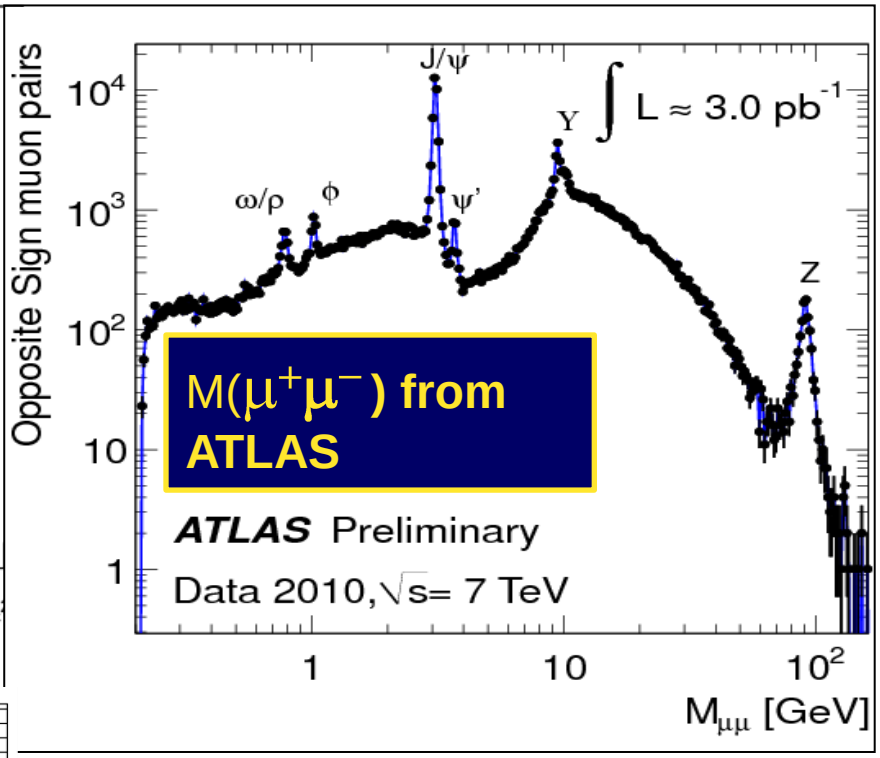
Reconstructed conversion point in the radial direction of $\gamma \rightarrow e^+e^-$ from minimum bias events (sensitive to X_0)

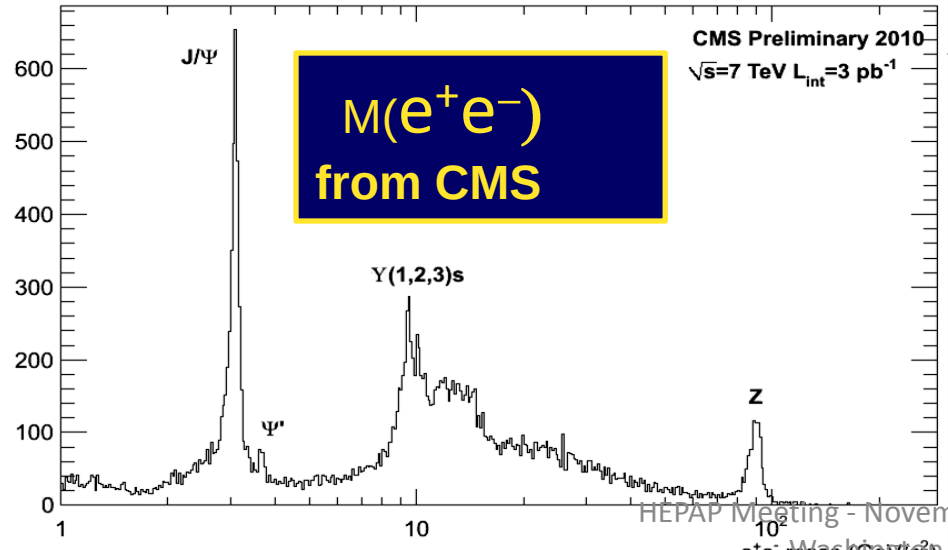
Goal is to know material to better than 5%
(e.g. for W-mass measurement)
Present understanding: at the level of ~ 10%

Dileptons in CMS and ATLAS



Invariant mass resolution at Z peak ~ 1%





- J/ Ψ: An excellent "candle" for detector commissioning and early physics (B-physics, QCD).
- Large samples of low-p_T muons to study Muons: trigger, ID, resol'n, abs. momentum scale in the few GeV range
- Also Υ-family and Z !

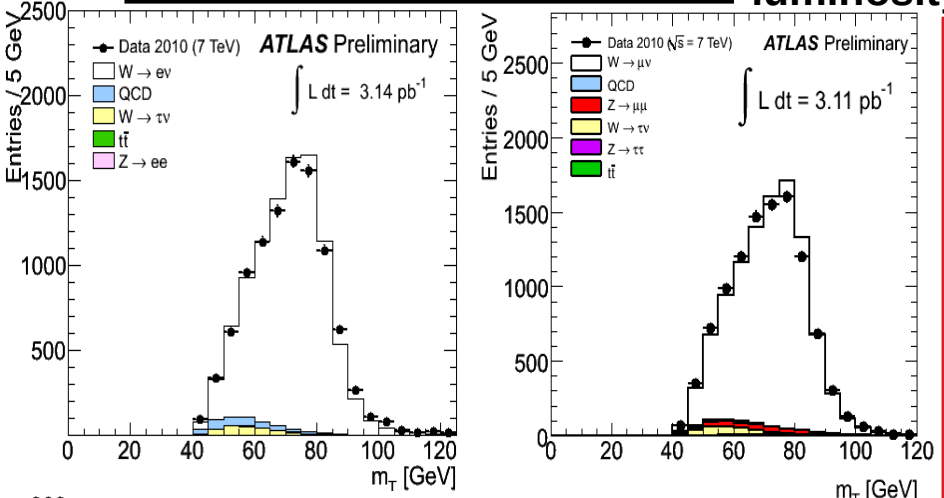
ATLAS Preliminary W/Z Cross-Sections

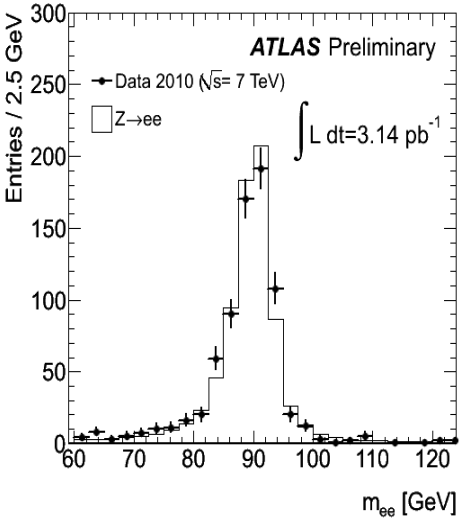
σ (W→ lν) = 9.96 0.23 (stat) 0.50 (syst) 1.10 (lumi) nb
σ (γ*/Z→ ll) = 0.83 0.06 (stat) 0.04 (syst) 0.09 (lumi) nb

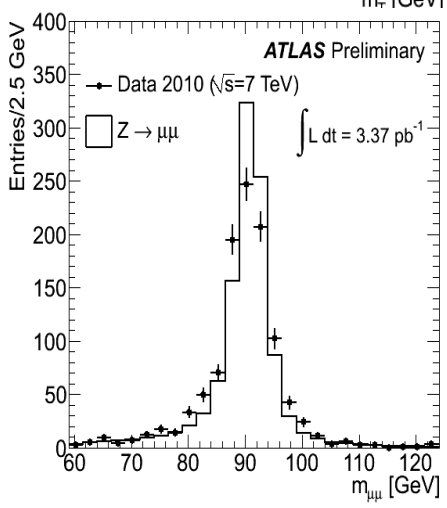
Update: Based on 3+ pb^{-1}

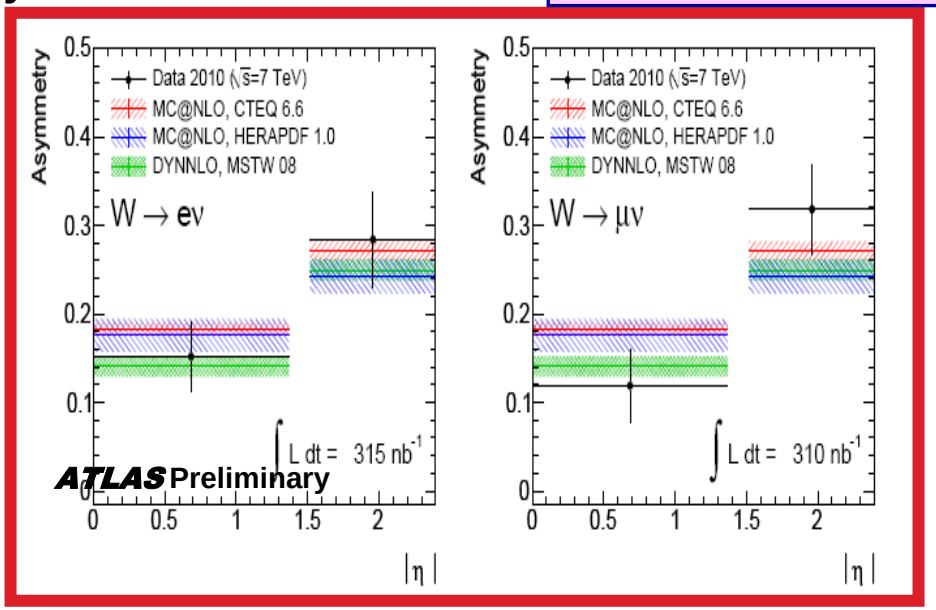
n.b. largest uncertainty is luminosity

Based on 300 nb^{-1}









$$A = \frac{\sigma(W \to \ell^+\nu) - \sigma(W \to \ell^-\nu)}{\sigma(W \to \ell^+\nu) + \sigma(W \to \ell^-\nu)} \neq 0$$

ATLAS measurement:
A = 0.200 0.022 (stat) 0.006 (syst)

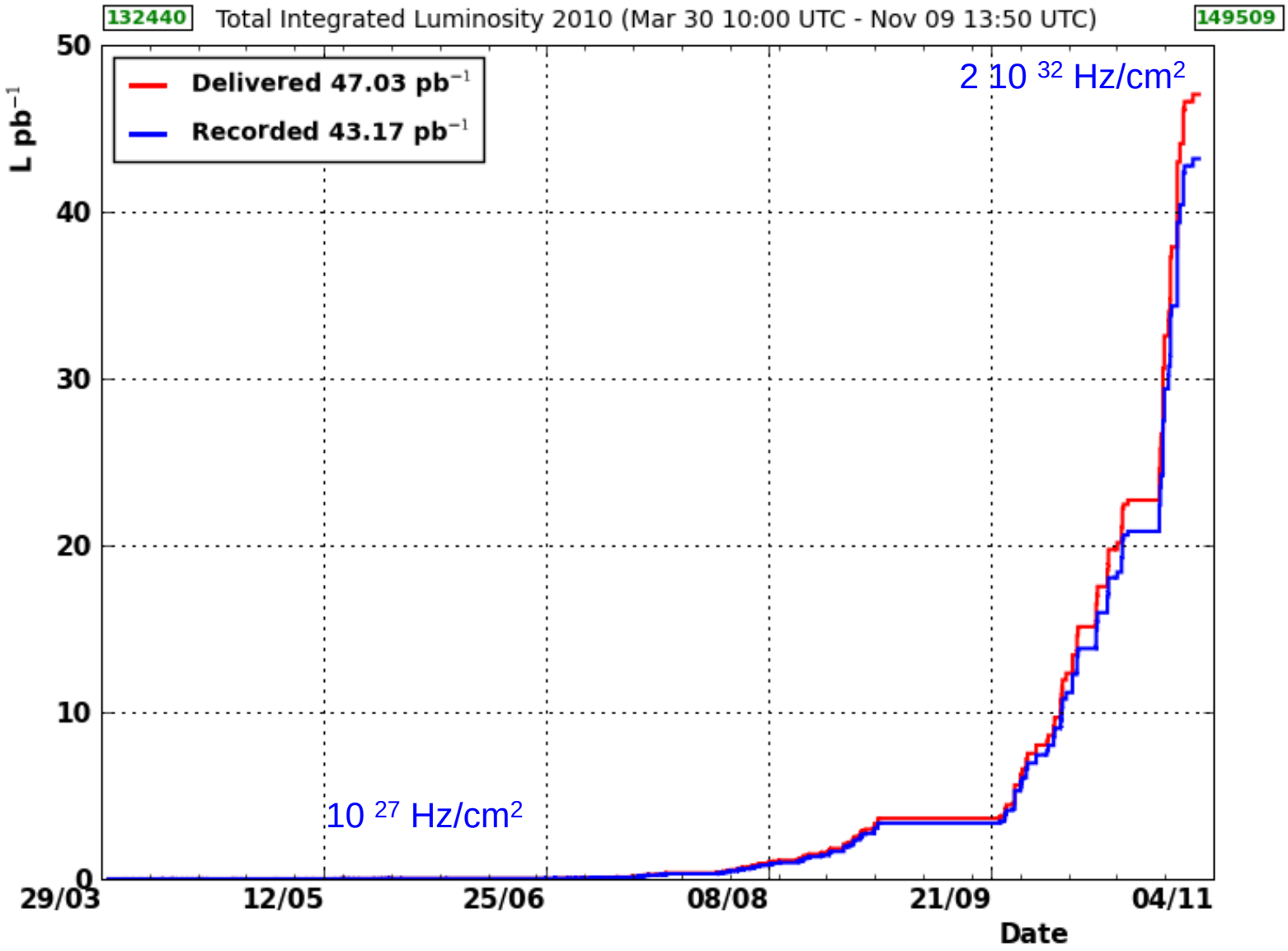
DC

CMS Backups

- Publications
- CMS Luminosity plot
- Distributed Computing Performance
- J/ψ Cross sections – prompt
- J/ψ Cross sections – non-prompt
- Strange particle production
- W and Z cross sections
- W^+ and W^- and Theory

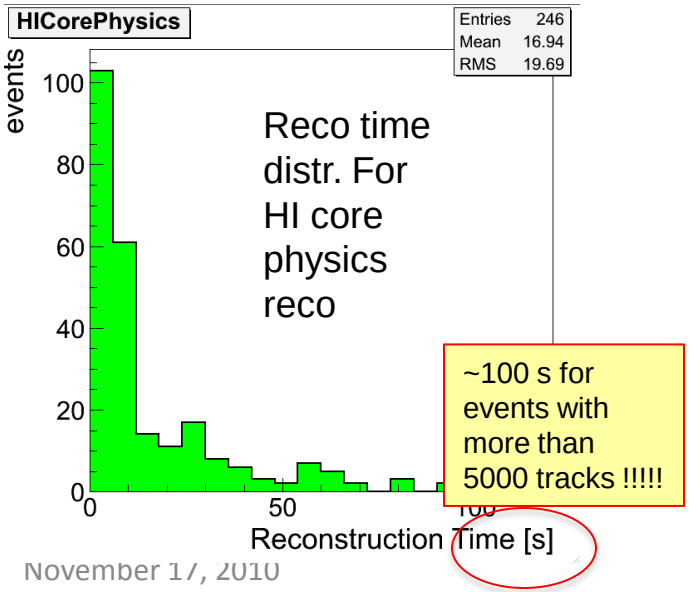
Physics publications

- First Measurement of the Cross Section for Top-Quark Pair Production in Proton-Proton Collisions at sqrt(s) = 7 TeV, arXiv:1010.5994, Accepted by PLB.
- Search for Quark Compositeness with the Dijet Centrality Ratio in pp Collisions at sqrt(s) = 7 TeV , arXiv:1010.4439, accepted by PRL
- Search for Dijet Resonances in 7 TeV pp Collisions at CMS, arXiv:1010.0203, accepted by PRL
- Observation of Long-Range, Near-Side Angular Correlations in Proton-Proton Collisions at the LHC, JHEP 09 (2010) 091
- First Measurement of the Underlying Event Activity at the LHC with sqrt(s) = 0.9 TeV, EPJC Online first 6th Nov, DOI 10.1140/epjc/s10052-010-1453-9
- Measurement of the charge ratio of atmospheric muons with the CMS detector, PLB 62 (2010) 83
- Transverse-momentum and pseudorapidity distributions of charged hadrons in pp collisions at s = 7 TeV, PRL 105 (2010) , 022002
- First Measurement of Bose-Einstein Correlations in proton-proton Collisions at s =0.9 and 2.36 TeV at the LHC, PRL 105 (2010) , 032002
- Transverse momentum and pseudorapidity distributions of charged hadrons in pp collisions at s = 0.9 and 2.36 TeV, JHEP 02 (2010) 041

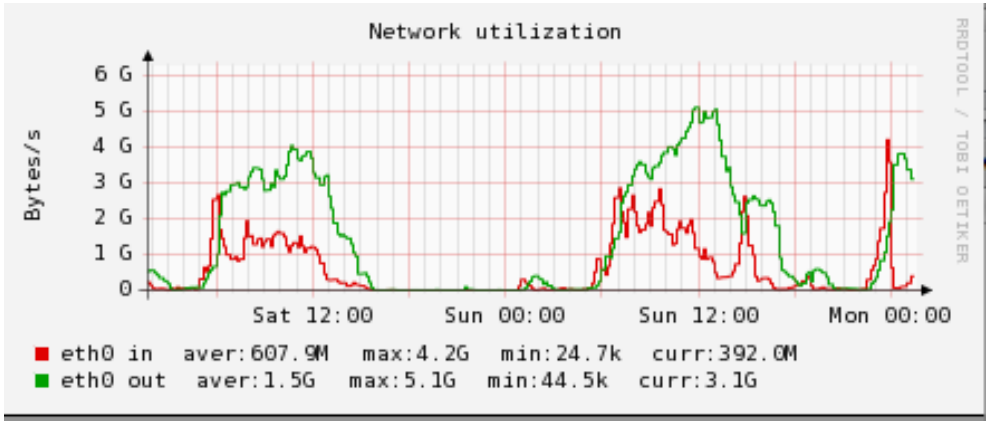

132440
Total Integrated Luminosity 2010 (Mar 30 10:00 UTC - Nov 09 13:50 UTC)
149509
Delivered 47.03 pb^{-1}
Recorded 43.17 pb^{-1}
2 10 ^{32} Hz/cm^2
10 ^{27} Hz/cm^2
L pb^{-1}
50
40
30
20
10
0
29/03
12/05
25/06
08/08
21/09
04/11
Date

CMS software/computing performance

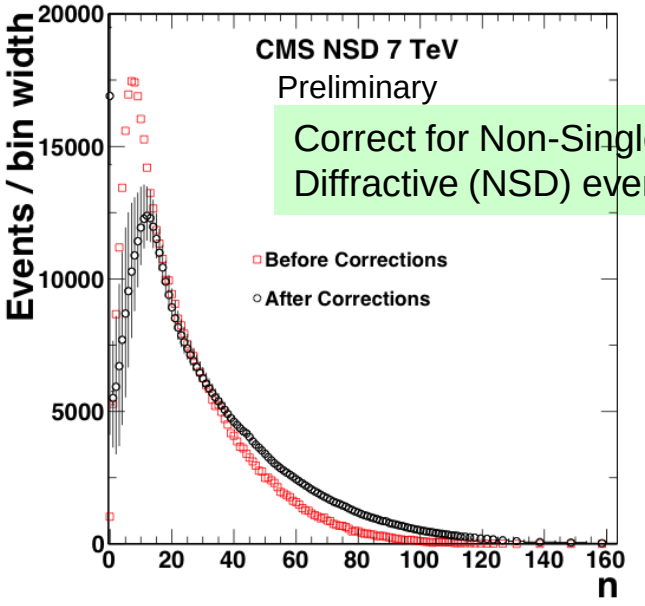
- Average time to Reco pp event (2 10^{32} Lumi triggers)= 2s
- Average time to Reco Heavy Ion event: 11 s
- Average time to process a L1 trigger at HLT: 40 10^{-3} s
- L1 Trigger rates pp: 70 KHz (limited by HLT CPU time)
- HLT output (logging) rates: 300-600 Hz (pp), ~200 Hz(HI)
- Prompt calibration loop commissioned: last period PP reco delayed by 48 hours to allow calibration constants to be used
- Full certification of reco within a week



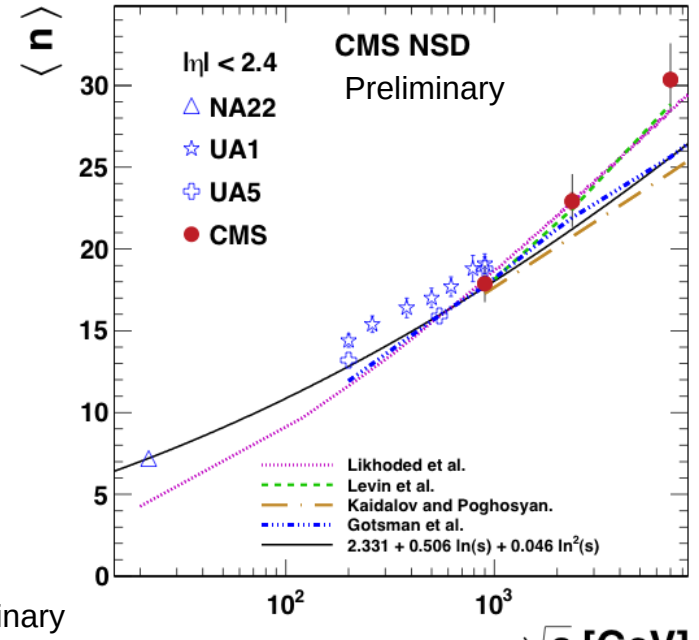
Castor I/O



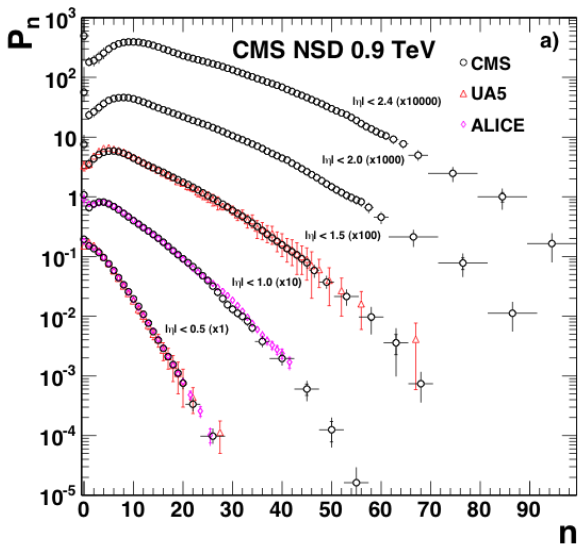
CMS Soft QCD: multiplicities

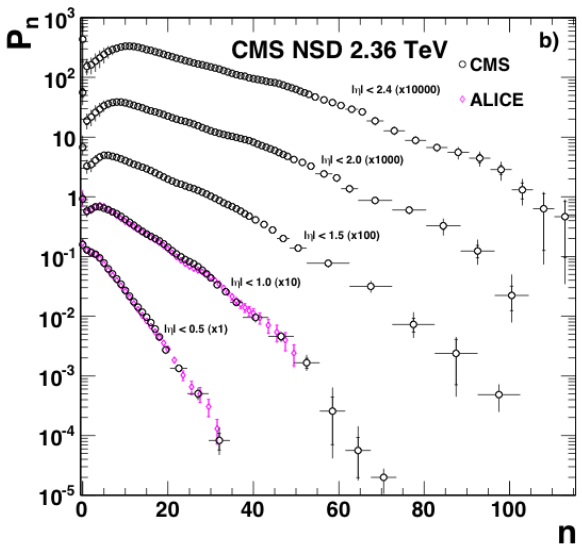


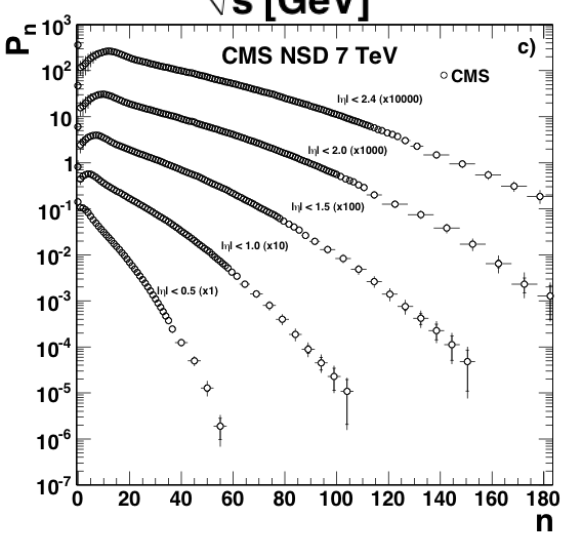
Correct for Non-Single Diffractive (NSD) events



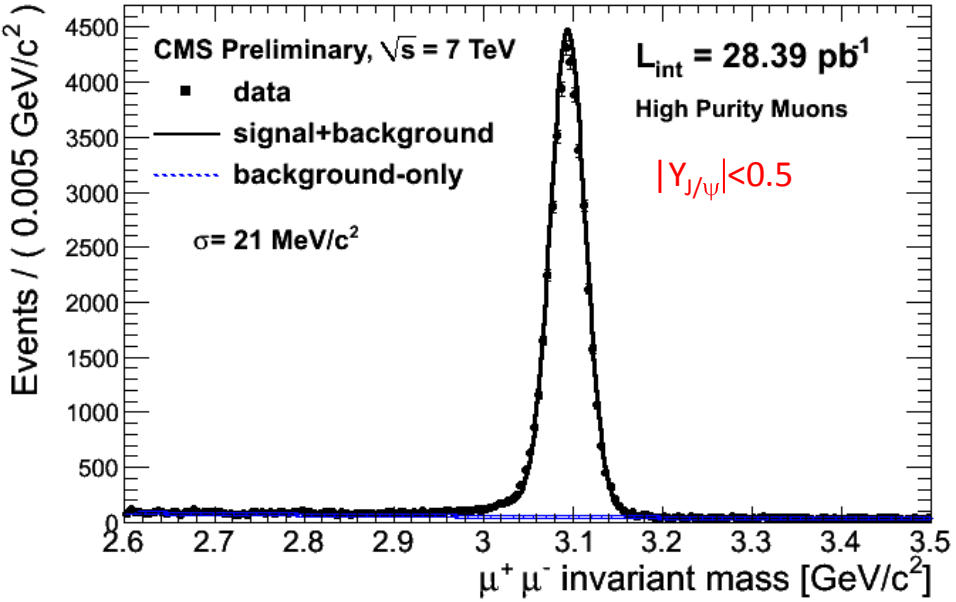
Preliminary

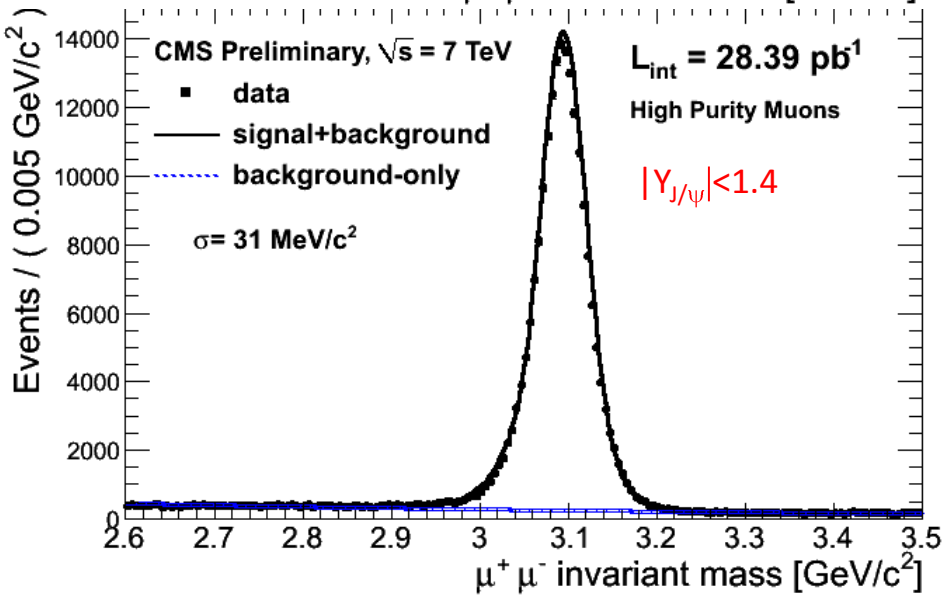


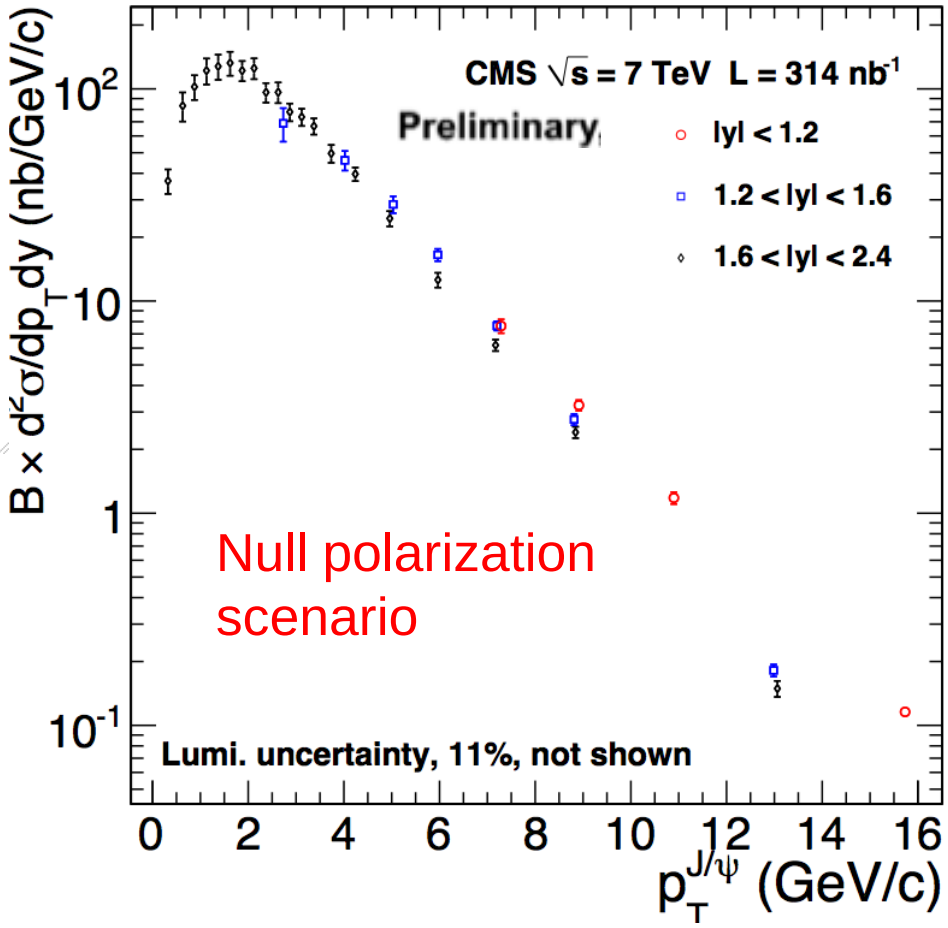




CMS J/ψ production cross sections



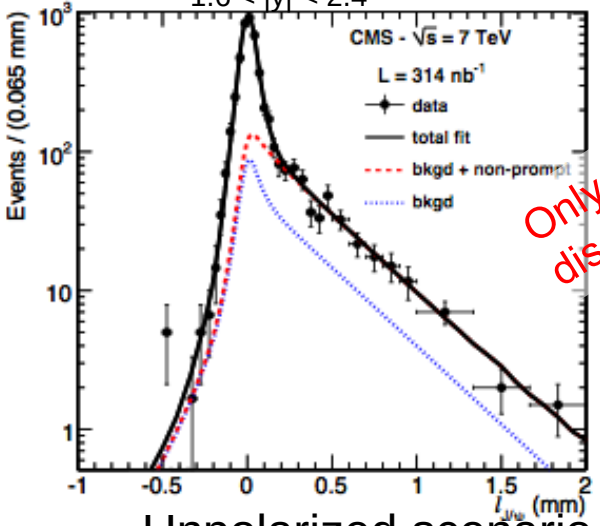




… and separating prompt/b decay

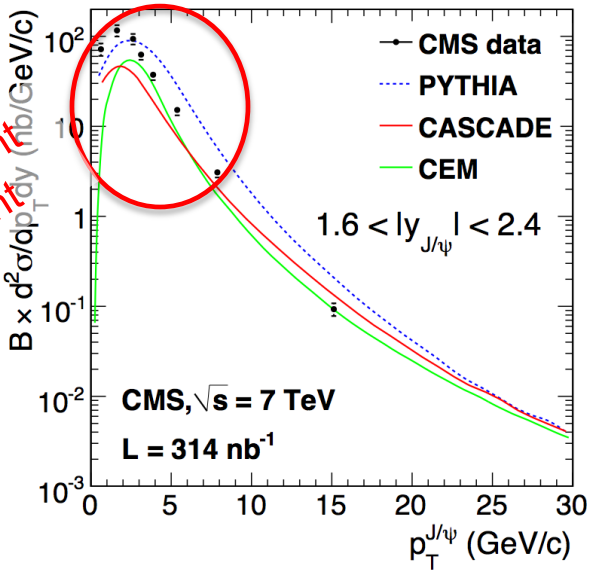
Transverse J/ψ flight distance in bins of p_t and η

$6.5 < p^{J/\psi} < 10$ GeV/c,
$1.6 < |y| < 2.4$

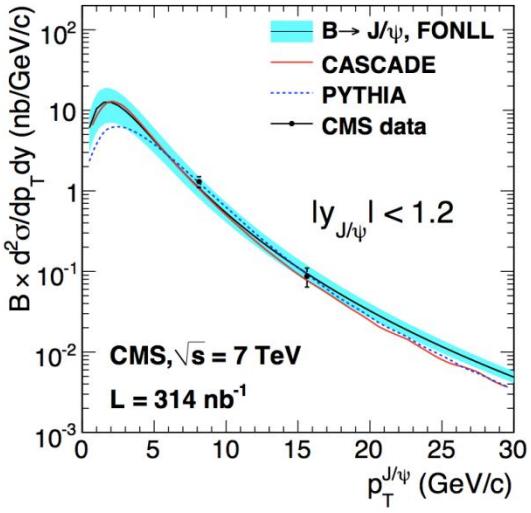


Only significant disagreement

Prompt diff. x-section



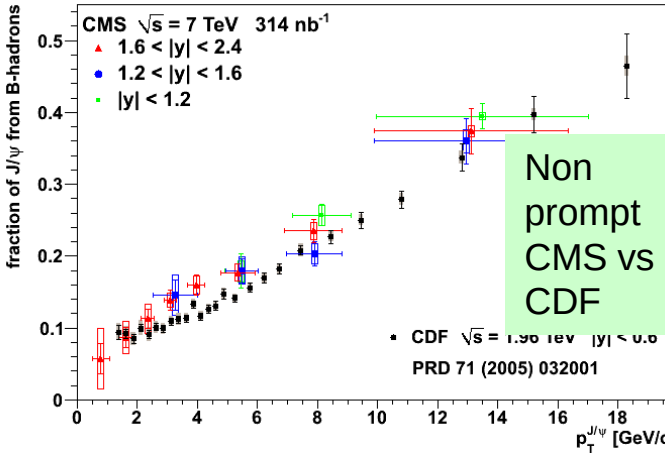
Non-Prompt diff. x-section



Unpolarized scenario :

$$BR(J/\psi \to \mu^+\mu^-) \cdot \sigma(\mathrm{pp} \to \text{prompt } J/\psi) = 196.7 \pm 3.8 \pm 10.7 \pm 21.6$$

$$BR(J/\psi \to \mu^+\mu^-) \cdot \sigma(\mathrm{pp} \to bX \to J/\psi X) = 53.3 \pm 2.2 \pm 4.6 \pm 5.9 \text{ nb}$$

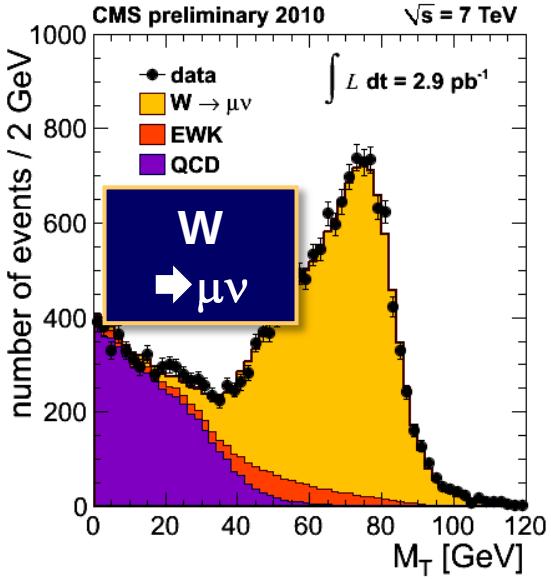


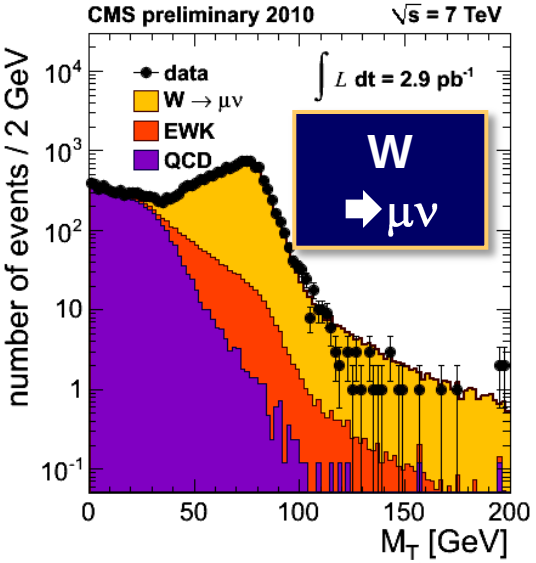
Non prompt CMS vs CDF

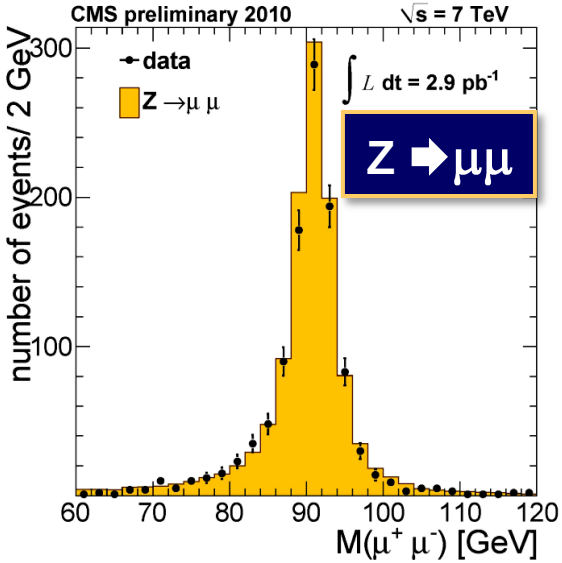
W and Z in CMS

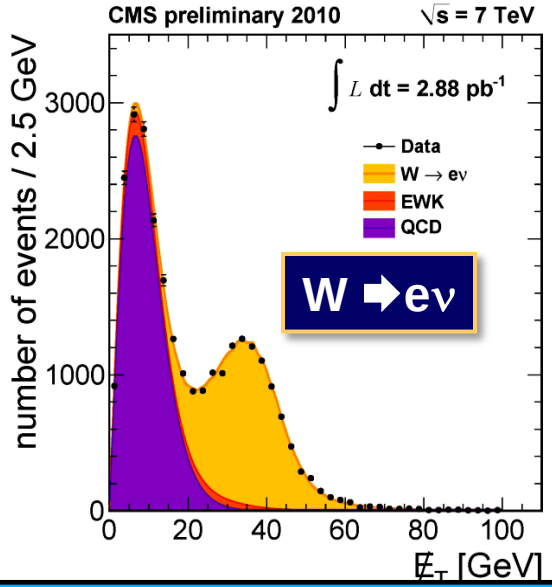
Update: Based on 3 pb^{-1}

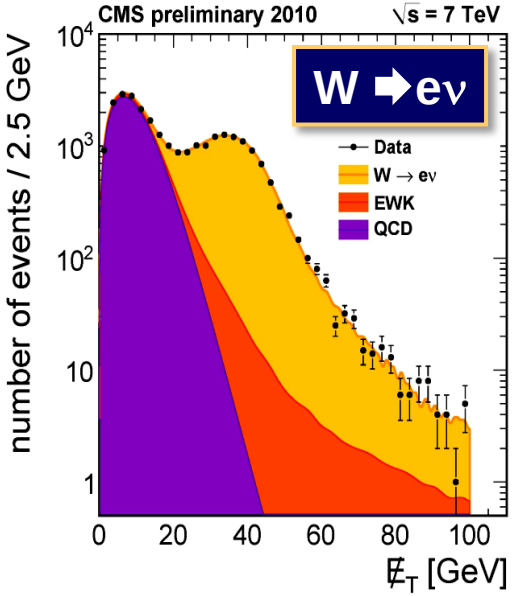
G. Tonelli

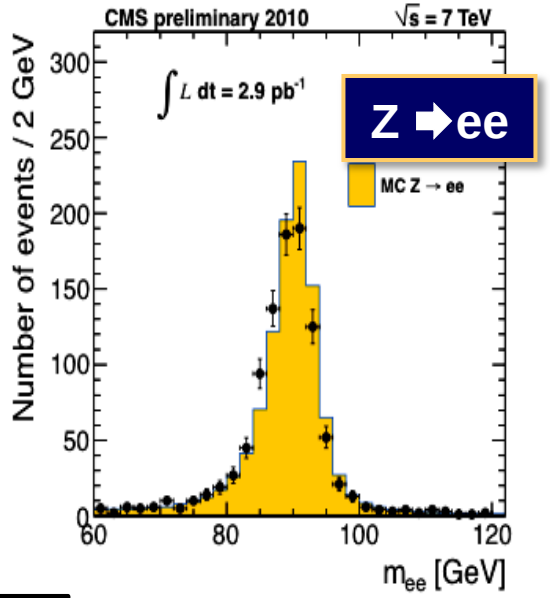










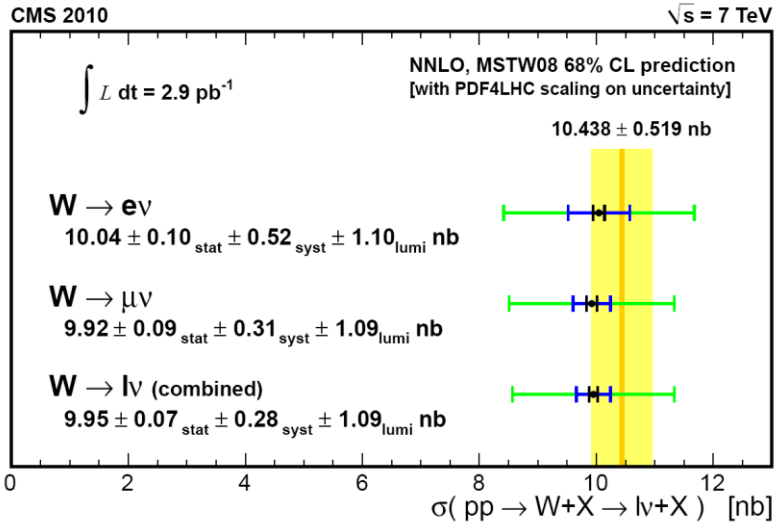


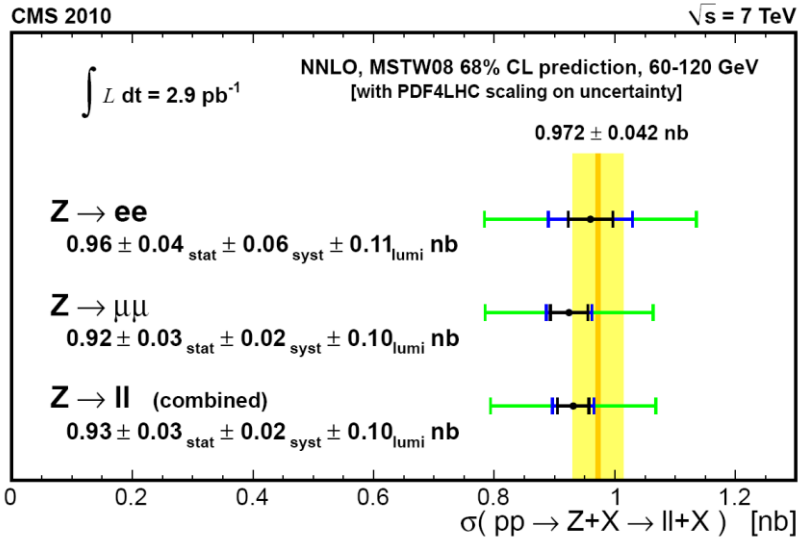
σ (W→ lν) = 9.22 0.24 (stat) 0.47 (syst) 1.01 (lumi) nb
σ (γ*/Z→ ll) = 0.88 0.07 (stat) 0.04 (syst) 0.10 (lumi) nb

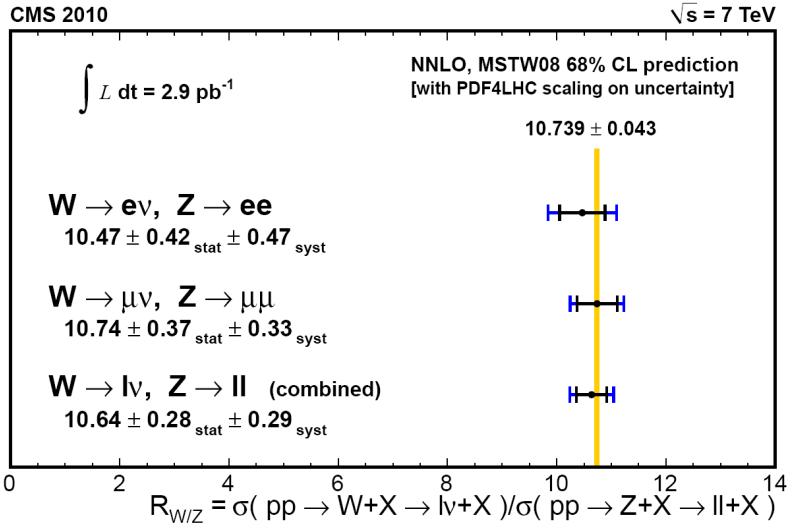
Based on 198 nb^{-1}

Electroweak: Z and W cross sections

Z and W cross sections and ratios

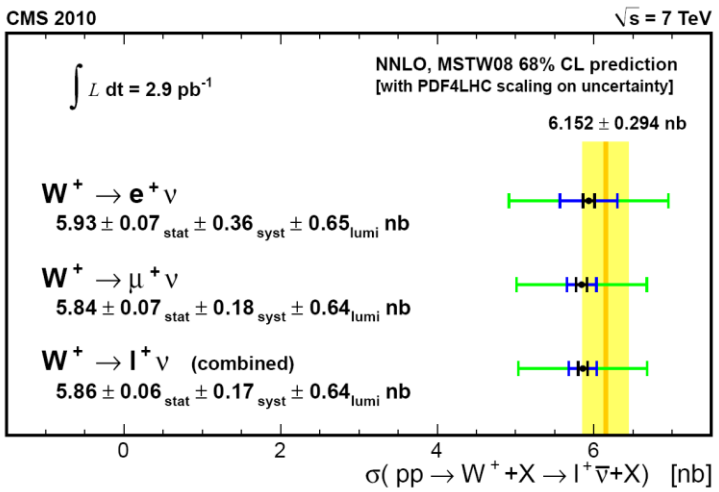


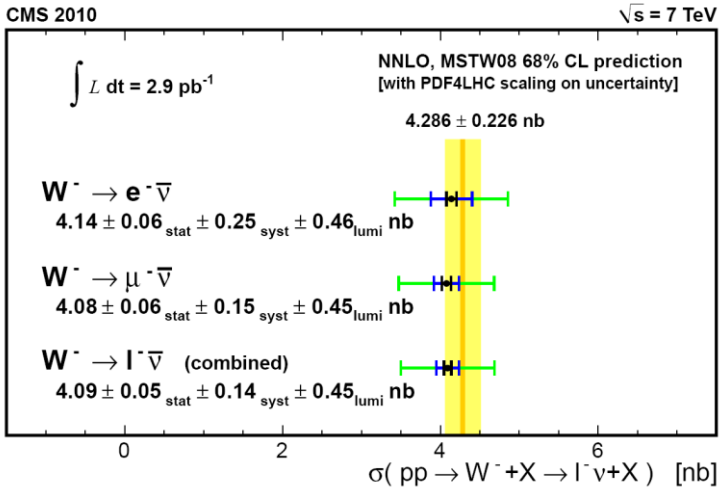




W^+ and W^- and theory

Clearly Lumi the area with largest potential of improvement





Lumi error